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ORIGINAL ARTICLES.

I.—Notes on the Trilobite Fauna of Devon and Cornwall.[1]

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(PLATE VII.)

THE material upon which the following descriptions are based was obtained chiefly by Mr. Ussher, who collected the Whiteway and Hestow Farm specimens. The Daymer Bay form was collected by Mr. John Pringle. For the new species of *Proetus* I am indebted to Mr. Claude H. Peter, Town Clerk, Launceston, who, through Mr. Clement Reid, kindly lent it for description. It is evident from the examination of this limited quantity of material that the British Devonian fauna is not yet fully known. We may expect the discovery of many species hitherto unrecorded in this country, which will be of interest from the possible comparative relationship with the fauna of foreign deposits. The accompanying illustrations were drawn by my colleague, Mr. H. H. Thomas, to whom I tender my best thanks.

PHACOPIDÆ.

Phacops (Trimerocephalus) anophthalmus, Frech. Pl. VII, Fig. 1.

1866. *Phacops cryptophthalmus*, F. Roemer: Zeitschr. d. d. geol. Ges., Bd. xviii, p. 674, pl. xiii, figs. 6, 7.
1871. ,, ,, E. Tietze: Palæontographica, Bd. xix, p. 126, pl. xvi, fig. 1.
1876. ,, ,, F. Roemer: Lethæa Palæozoica, i, pl. xxxv, fig. 18.
1894. ,, (*Trimerocephalus*) *anophthalmus*, Frech: Die Karnischen Alpen, p. 270.
1895. *Trimerocephalus typhlops*, Gürich: Verhdl. d. Russ.-k. Min. Geol. zu St. Petersburg, Bd. xxxii, p. 359, pl. xv, fig. 7.
1900. *Phacops* (*Trimerocephalus*) *anophthalmus*, Drevermann: Jahrb. d. k. preuss. geol. Landesanst., Bd. xxi, p. 117.

Description.—The *cephalon* is broadly semicircular, the length being about 8 mm. and the greatest breadth about 14 mm. The posterior limit is almost straight. The marginal border is fairly broad, and extends from the rounded genal extremities to the frontal margin of the glabella, and is continued anteriorly as a narrower and less distinct rim to the overhanging frontal lobe.

[1] By permission of the Director of the Geological Survey.

The fairly tumid *glabella* is markedly pentagonal, with a low curvature on the anterior margin, and is bounded by strong dorsal furrows enclosing an angle of *circâ* 50°. Its length in our specimen is 8 mm., and the greatest breadth near the frontal extremity is approximately 7 mm. The basal furrow is rather shallow at the centre, but deepens where it joins the above-mentioned dorsal furrows. The basal ring is slightly elevated and fairly broad, while the adjacent occipital furrow is shallow where it bounds the basal ring, and becomes deeper towards the cheek margins.

The *cheek-areas* are triangular, elevated, and fall gradually towards the glabella, but steeply outwards towards the marginal border. No trace of eyes is to be seen.

Locality and Horizon.—This specimen was obtained in the Upper Devonian purple and green slates of Daymer Bay, Cornwall. Mr. Dewey informs me that these beds are much overthrust and contorted on the south side of the bay, where they are overlain by sand. On the north side they are more exposed, and have been found to be highly fossiliferous in a low reef of rock near the end of the lane leading from Trebetheric to the sands. West of this lane and by the first hedge along the cliff, a fault, east and west in direction, throws down the purple and green slates, and brings into sight black shaly slates full of pyritous casts of cephalopods and lamellibranchs. The described trilobite was found on the foreshore, 50 yards west of the above-mentioned hedge, in association with pygidia of *Phacops latifrons* (Bronn), *Tentaculites* cf. *tenuicinctus*, F. A. Roemer, and poorly preserved brachiopod remains. The black slates have yielded *Tornoceras* sp., *Orthoceras commutatum*, C. G. Giebel, *Buchiola* cf. *semiimpressa*, Drevermann, and a small form referable to *Modiella pygmæa* (Conr.).

Remarks.—Owing to long exposure to the sea the specimen is not as well preserved as could be desired. The frontal lobe of the glabella has been somewhat worn anteriorly, and parts of the marginal border are destroyed. The same specimen has been referred to in a former paper under the name *Phacops* (*Trim.*) cf. *anophthalmus* (16, p. 100).

The name *anophthalmus* was given by Professor Frech (4, p. 270) to *Phacops cryptophthalmus* of F. Roemer from the Upper Devonian of Kielce, Poland (13, p. 674, pl. xiii, figs. 6, 7), and of Tietze (18, p. 126, pl. xvi, fig. 1), from the Clymenienkalk of Ebersdorf (not *cryptophthalmus* of Emmrich). Professor Gürich described the same form under the name *Trimerocephalus typhlops*, nov. nom., from the middle Upper Devonian of Kadzielnia, Poland (6, p. 359, pl. xv, fig. 7).

Phacops (Trimerocephalus) aff. cryptophthalmus, Emmr. (as interpreted by Gümbel). Pl. VII, Figs. 2, 3.

Description.—The general contour of the *cephalon* is semicircular, with a practically straight posterior margin and a breadth almost twice the length. The whole surface is covered with small granules.

The somewhat flattened *glabella* is pentagonal in outline, and is bounded by deep dorsal furrows enclosing an angle of *circâ* 80°. The posterior part has a deep basal furrow and a fairly elevated, convex, basal ring. The occipital ring is imperfectly preserved, but appears to have been as broad and elevated as the basal ring.

The triangular *cheek-areas* rise to the level of the glabella, and slope fairly steeply towards the latter, but more gently outwards to a narrow groove bounding the marginal border of the head-shield. This border is broad and is continued from the fairly angular genal extremities to the glabella, where its outer margin appears to be continuous, as viewed from the dorsal side, with the anterior limits of the frontal lobe.

The *eyes*, of which the left one is preserved, are each situated upon a broadly elliptical lobe at the anterior extremity of the cheek-area. Eight circular facets are present, and are arranged in two sub-crescentic rows concave to the antero-lateral margin of the head-shield; there are five facets in the outer and three in the inner row.

Locality and Horizon.—This form was found in the Upper Devonian greenish-grey slates of Whiteway Farm-yard near Ideford, Devonshire. In association with it are found *Dechenella ussheri*, sp. nov., *Phacops* (*Trim.*) *tripartitus*, sp. nov., *Proetus* spp., *Posidonomya venusta* (Münst.), *Buchiola* sp., and *Entomis serratostriata* (G. & F. Sandberger). These beds were identified by Professor Kayser some years ago as equivalent to the Cypridinen Schiefer (9, p. 185; 20, p. 513).

Remarks.—The same specimen is referred to in a previous paper (16, p. 100) as being allied to *Phacops* (*Trim.*) *cryptophthalmus*, Emmr. As *cryptophthalmus* has been variously applied by different authors (17, p. 168), it is well to emphasize that its use in this case is in accordance with Gümbel's interpretation (5, pl. A, figs. 7–9). Gümbel's figure shows a marginal border which narrows more rapidly anteriorly and a more angular antero-lateral margin of the glabella. Comparison with a figure alone is unsatisfactory, since allowance has to be made for imperfections in the drawing as well as for the different positions in which the specimen may have been held.

A resemblance also exists with *Trimerocephalus cyclophthalmus*, K. Walther (21, p. 318, pl. xv, fig. 1), from the Styliolinen Schiefer of Schaderthal. The latter has a more curved posterior margin of the head-shield, more rounded genal extremities, apparently a less elongated glabella, and more eye facets, which also differ in their arrangement.

The eye of this species is seen to consist of two sub-crescentic rows concave to the antero-lateral margin of the head-shield, while that of *Ph.* (*Trim.*) *pentops*, Ivor Thomas (16, p. 97, pl. iii, figs. 1–4), is made up of one sub-crescentic row convex to the same margin.

The question of the development of eyes in *Phacops* has been discussed by Dr. J. M. Clarke in a valuable paper on the visual area of *Phacops rana*, Green (2*a*). Among other important conclusions he finds that "a definite relationship exists between the number of lenses of the eyes and the size (i.e. the age) of the animal" (2*a*, p. 257), and that "the number of lenses increases from youth to maturity and decreases from maturity to senility" (2*a*, p. 258). The deduction that "the primary lenses probably appeared in a single or double row, a visual line parallel to the margins of the orbital node" (2*a*, p. 261), is of particular interest in the consideration of the above-mentioned forms. Dr. Clarke, in a letter calling my attention to the above paper, expresses the opinion that *Trimerocephalus* is particularly interesting "in respect to its senile decline of visual surface". In

agreement with this opinion forms such as *Ph.* (*Trim.*) aff. *cryptophthalmus* and *Ph.* (*Trim.*) *pentops* may represent senile stages in the phylogeny of the genus *Phacops*. On the other hand, the small number of eye facets may be the result of specialization and not of degeneration.

PHACOPS (TRIMEROCEPHALUS) TRIPARTITUS, sp. nov. Pl. VII, Figs. 4, 5.

Description.—The smooth *cephalon* shows a general parabolic outline, and in the case of one specimen has a length of *circâ* 3·3 mm. and breadth of 4 mm. approximately.

The tumid *glabella* is regularly curved anteriorly, but somewhat constricted towards the low narrow basal ring, which bears terminal tubercles, one at each extremity. Lateral furrows are not traceable on the frontal lobe. The bounding dorsal furrows are deep, and enclose an angle of about 73°. The ratio of the length to the greatest breadth = 9 : 8. The occipital furrow is fairly broad and almost equal in width to the well-marked and elevated occipital ring.

The tumid *cheek-areas* are triangular, and fall steeply towards the glabella, but more gradually outwards towards the marginal border. The latter is a fairly broad and flattened area continued from the rounded genal extremities to the antero-lateral border of the glabella. It is impossible to trace it still further anteriorly in the specimens at present at my disposal.

Eyes are preserved in one of the specimens, and are each situated upon the extreme anterior corner of the triangular cheek-areas. The facets are circular and few in number.

Locality and Horizon.—Four fairly complete heads, together with many fragments, were collected from the same locality and horizon as *Phacops* (*Trim.*) aff. *cryptophthalmus*, etc.

Remarks.—This form is closely related to *Phacops* (*Trim.*) *acuticeps*, Kayser, from the Upper Devonian limestones of Martenberge, near Adorf (10, p. 288, pl. xiii, fig. 6). It differs from that species, among other details, in the possession of a straighter posterior margin and less angular genal extremities of the head-shield, in the absence of well-marked lateral furrows on the frontal lobe of the glabella, in the less angular frontal margin, and less continuity in the curvature of the outer border of the marginal area with the frontal extremity.

A similarity also exists with *Phacops* (*Trim.*) *micromma*, F. A. Roemer, as interpreted by Dr. Karl Walther (21, p. 317, pl. xv, fig. 6). The German form, however, has well-marked lateral furrows on the frontal lobe of the glabella, and the base of the latter portion is less constricted than in our species. Roemer's figure (15, p. 81, pl. xii, fig. 25) seems very much reconstructed, and is hardly comparable with the British form.

PROETIDÆ.

Zittel (25, pp. 476, 477) divides this family into the genera *Proetus* (Silurian, Devonian, and Carboniferous), *Arethusina* (Silurian and Devonian), *Cyphaspis* (Silurian and Devonian), *Harpides*, *Carmon*, *Cyphoniscus* (Ordovician), and *Phillipsia* (Devonian, Carboniferous, and

Permian), with its subgenera *Griffithides*, *Pseudophillipsia*, *Brachymetopus* (Carboniferous), and *Dechenella* (Devonian). Oehlert (12, p. 127), however, gives a slightly different division of the group. He separates the forms into two sections: Section A, Proetidæ, with glabella tapering anteriorly and including the genera *Proetus*, *Dechenella*, and *Brachymetopus*, together with *Phaeton* (Silurian), a subgenus of *Proetus*; Section B, Phillipsidæ, with the glabella widening anteriorly: these include the genera *Phillipsella* (Silurian) and *Phillipsia*, together with *Griffithides* as a subgenus of the latter. In a later note (12, p. 141) Oehlert withdraws the name *Phillipsella* in favour of Novák's *Phillipsinella*, which had priority.

PROETUS DUNHEVIDENSIS, sp. nov. Pl. VII, Fig. 6.

Description.—The general shape is elongate oval, the margins bordering the thorax longitudinally being sub-parallel. The total length is 17·5 mm. approx., the breadth at the centre of the thorax being about 11 mm. In profile there is a sharp rise from the posterior border of the pygidium to the hindmost ring of the thorax, and from this point there is a gentle downward slope to the glabella. The slope forwards along the surface of the glabella is steeper and more like that of the pygidium until the frontal margin is reached, where a somewhat sharper fall towards the marginal border occurs.

The *cephalon* is obtusely parabolic, the breadth being slightly more than twice the length. The anterior margin is regularly convex, while the posterior boundary is slightly concave to the thorax. The genal angles are produced into long, gradually tapering spines, one of which is traceable to the seventh pleuron of the thorax.

The *glabella* is elongate oval, slightly narrowing towards the rounded anterior end. The ratio of the length to the greatest breadth is about 5 : 4. Under strong magnification there is an indication of three faint furrows on either side, two of which occur close together on the margin near the anterior end of the eye, while the other runs inward and backward from a point near the middle of the eye, separating off a small indistinct basal lobe. The occipital furrow is fairly deep and narrow, and bounds a well-marked occipital ring. The latter arches forward in the centre and is slightly rounded, and approximately the same width as the thoracic axial rings. In front of the glabella and continued down to the genal spines on either side is a well-marked apparently flattened border which gradually narrows anteriorly. Owing to lateral compression, which has affected most of the left side of the specimen described, this border is imperfect to the left, but is better preserved and more of the natural width to the right of the glabella.

The *fixed cheeks* are elongated and narrow, with a triangular, roughly equilateral, anterior and a narrower, also triangular, posterior portion. The eye-lobe is comparatively low and not prominent. The *facial sutures* cut the anterior border of the head-shield at a distance from one another slightly greater than the length of the glabella. They run gradually inwards posteriorly from their anterior terminations, then curve outwards round the eye-lobe, and ultimately cut the occipital ring obliquely at a low angle, reaching the posterior margin

about half-way between the axial furrows and the base of the genal spine.

The *free cheeks* are triangular, fairly elevated, and slope rather steeply outwards to the marginal border. The bounding marginal and occipital furrows meet at an angle of about 60°. The *eyes* are prominent and sub-crescentic. They are situated on the summit of the free cheeks near the glabella, extending to almost half the length and rising nearly to the height of the glabella. The facets appear to be circular, minute, and very numerous.

The *thorax* is nearly twice the length of the head-shield, and consists of nine segments, with a prominent, elevated, and rounded axis very gradually tapering posteriorly. This axis is about four-thirds the width of the pleural portion. The axial furrows are well marked. The pleura run out at first practically at right angles to the axis, and are then deflected backwards at the fulcrum, situated about two-thirds of the width of the pleural portion from the axis. Each pleuron is divided into two parts by a furrow. The anterior part is deflected backwards gradually at the fulcrum, and overlaps the posterior and less deflected portion near the margin. The state of preservation of some parts of the thorax makes it impossible to give greater details.

The *pygidium* is semicircular and about five-eighths the length of the thorax. The axis is prominent, convex, and rapidly tapers to a blunt extremity. Seven rings can be clearly seen, while one or two practically obsolete ones may also exist. The lateral lobes are too poorly preserved for clear discrimination. The marginal border is very well developed, its width at the posterior extremity being about two-fifths the length of the pygidium. A gradual narrowing of this border takes place towards the anterior terminations, and its surface retains traces of ornamentation by furrows parallel to the margin.

Locality and Horizon.—A single specimen of this trilobite was obtained in the Upper Devonian of South Petherwin, Cornwall, and was collected in an old quarry on the eastern side of the road at Landlake. This exposure seems, according to Mr. Clement Reid, to have yielded all the best of the Petherwin fossils; the quarry has now been filled up with town refuse from Launceston.

Remarks.—The two forms which show most resemblance to this species are *Proetus nevadæ*, Hall (7, p. 219, pl. xxiii, fig. 19), from the lower horizon of the Devonian limestone of Comb's Peak, Eureka District, Nevada, and *Proetus superstes*, Barr. (1, pl. xv, figs. 5–9), from étage H. Compared with the former, our species is less elongated, has a narrower border of the head-shield, possesses much longer genal spines, a less number of thoracic rings, and a considerably broader marginal border and more tapering axis of the pygidium.

Compared with *Proetus superstes*, the Cornish species appears to be more elongated, has a more curved posterior margin of the head-shield, possesses smaller eyes, much longer genal spines, slightly different facial sutures, a more elevated axial region of the thorax and pygidium, and a considerably broader marginal border and blunter axis of the pygidium.

The specific name *dunhevidensis* is derived from Dunhevid, the old British name for Launceston.

PROETUS, sp. *a*. Pl. VII, Fig. 7.

Description.—The elongated *glabella* has a length of 8 mm. and greatest breadth at its base of 5·5 mm. approx. It tapers gradually from the occipital groove to about the middle of its extension anteriorly, where a slight constriction occurs. Thence the tapering continues slowly to the rounded frontal extremity. The bounding furrows enclose an angle of about 19° anteriorly. Three pairs of lateral furrows are plainly discernible. The posterior pair curve backwards, and are continued faintly to the occipital furrow, enclosing two sub-rhomboidal basal lobes. The middle pair also curve slightly backwards, but disappear nearly half the distance to the centre of the glabella. The anterior pair are still shorter. The occipital ring, which is poorly preserved, appears to have been fairly broad and elevated with a narrow occipital groove. The head-shield terminates in a raised rim of low curvature and separated from the frontal extremity of the glabella by a fairly broad concave space. The *facial sutures*, of which the left one is best preserved, cut the margin of the head-shield at a distance from one another nearly equal to the length of the glabella. They proceed backwards and slightly inwards from the frontal margin to about the middle of the glabella, then become deflected in a short curve outwards. The further course cannot be traced in consequence of incomplete preservation. A part of the right cheek is preserved, but is too poor for description.

Locality and Horizon.—This fragment of the head-shield was collected at the same locality and horizon as *Ph.* (*Trim.*) aff. *cryptophthalmus*, *Ph.* (*Trim.*) *tripartitus*, sp. nov., etc.

Remarks.—The glabella has a general resemblance to that of *Proetus dillensis*, Drevermann, from the Upper Devonian Clymenien Kalk of Langenaubach (3, p. 119, pl. xiii, fig. 9). The British form is much larger, and differs also in the possession of the raised anterior rim and a less regularly tapering glabella.

PROETUS, sp. *b*. Pl. VII, Fig. 8.

Description.—This *pygidium* is semicircular in outline, and has a length of about 2·5 mm. and greatest breadth of 4·5 mm. approx. The axis is well marked, elevated, and tapers very gradually to a blunt end posteriorly. About six fairly broad rings can be recognized. The pleura, of which six can be seen, curve very gradually outwards and backwards from the prominent groove bounding the axis. They broaden slightly in their course to the marginal border, and are divided into two well-marked portions by a narrow furrow. The two parts appear to diverge slightly from each other as they approach the margin. A well-developed flattened border is present, and is as wide as the posterior end of the axis.

Locality and Horizon.—The same as the preceding form.

Remarks.—A certain resemblance exists with the figures of young specimens of *Proetus superstes*, Barr., from étage G (2, pl. xvi, figs. 4, 5). The axis of the latter is more tapering and the marginal border is narrower.

The above described form is probably new, but it seems inadvisable to describe it as such without specimens of the head region.

PROETUS, sp. *c.* Pl. VII, Fig. 9.

Description.—The general outline of the *pygidium* is semicircular, and has a length of about 5 mm. and greatest breadth of about 10 mm. The broadly convex axis has ten rings, and tapers very quickly from the anterior portion, where the width is nearly as great as the whole length of the axis. The flattened pleura curve slightly backwards and number at least ten. Some of the better preserved parts show indications of a subdivision of each pleuron into two portions by a narrow furrow. The marginal border is very narrow, but well defined.

Locality and Horizon.—As the preceding form.

Remarks.—Compared with *Proetus*, sp. *b*, the axis of the latter is less tapering, the segments both in the axis and pleural region are fewer, and the marginal border is much broader.

DECHENELLA USSHERI, sp. nov. Pl. VII, Fig. 10.

Description.—The *cephalon* is almost semicircular, and possesses a narrow, flattened marginal border. The straight posterior margin forms the greatest breadth, and measures approximately 6·5 mm., while the greatest length of the head-shield is about 4 mm. An angle of nearly 70° is enclosed by the genal extremity, which is not produced into a spine.

The prominent, roughly triangular, and fairly tumid *glabella* is well demarcated, and tapers considerably towards the rounded frontal margin. The angle formed by the bounding dorsal grooves anteriorly = 41° approx. Three well-marked pairs of lateral furrows are present, the anterior pair being the shortest and of least depth, while the posterior furrows are very deep and run in a low curve to the occipital groove. In this manner two tumid, triangularly shaped lobes are separated off at the posterior portion. The occipital ring is only partly preserved, but appears to have been fairly prominent and narrow.

The *facial sutures* cut the anterior border at a distance of nearly 3 mm. apart. They run gradually outwards from this point of intersection, then curve inwards posteriorly to within a short distance of the glabella, and after a slightly curved course turn outwards rather sharply, reaching the posterior margin at a low angle about two-thirds of the distance between the base of the glabella and the genal angle. The *eyes* are not preserved.

The *cheek-areas* are elevated to almost the height of the glabella, and gradually slope outwards to a flattened region adjacent to the marginal border.

Locality and Horizon.—The same as *Phacops* (*Trim.*) *tripartitus*, sp. nov., etc.

Remarks.—The name *Dechenella* was first employed by Professor Kayser (11, p. 703) for those members of the Proetidæ with very tapering and strongly lobed glabella.

The glabella of our form shows a certain resemblance to that of *Dechenella verneuili* (Barr.), as interpreted by Professor Kayser (11, p. 705, pl. xxvii, figs. 1–5). In most other respects the two forms differ considerably. Thus the British specimen has no genal spine,

the general outline is semicircular and not parabolic, the cheeks do not show a sudden elevation, the facial sutures have a different course, while the posterior margin of the head-shield is straighter and the marginal border is narrower.

Compared with *Dechenella haldemanni* (Hall) (8, pl. xxi, figs. 7–9; 7, pl. xxi, figs. 7–9, pl. xxiii, figs. 13–15), from the Hamilton Beds of North America, *D. ussheri* differs, among other respects, in the more gradual tapering of the glabella, in the different course of the facial sutures, the greater breadth compared with the length, the greater prominence of the posterior pair of lateral furrows, and differently shaped basal lobes.

It differs from *Dechenella rittbergensis*, Zimmermann (24, p. 119, pl. i, fig. 4), of which only a part of the head-shield is described, in the longer and slenderer character of the glabella, as well as the different arrangement and prominence of the lateral furrows.

The glabella of *Dechenella romanovski*, Tschernyschew (19, p. 167, pl. i, figs. 4–8), is considerably broader compared with its length than that of our form.

The only other *Dechenella* described from British deposits is *D. setosa*, Whidborne (22, p. 27, pl. ii, fig. 15). *D. ussheri* has a broader head-shield relatively to the length, a straighter posterior margin, a slenderer glabella with more prominent posterior lateral furrows, and, finally, different facial sutures.

PHILLIPSIA MINOR, H. Woodward, 1884. Pl. VII, Fig. 11.

1884. *Phillipsia minor*, H. Woodward. A Monogr. of the British Carbonif. Trilobites: Palæontogr. Soc., p. 68, pl. x, figs. 5, 6*a*, *b*, 7, 8*a*.

1895. ,, ,, H. Woodward, in Hinde & Fox. "On a well-marked Horizon of Radiolarian Rocks in the Lower Culm Measures of Devon, etc.": Quart. Journ. Geol. Soc., vol. li, p. 646, pl. xxviii, fig. 2.

Description.—A somewhat abraded *pygidium*, measures about 4 mm. in length and approximately 4·5 mm. in greatest breadth, and has a general parabolic contour. The rounded and elevated axis tapers fairly rapidly, and reaches a distance of 0·9 mm. from the posterior margin. Owing to the abrasion only twelve segments can be seen. The ten prominent lateral pleura are separated from the axial region by a strong furrow, and curve slightly backwards towards the lateral margins, where they bifurcate. The broad marginal border narrows gradually anteriorly, and is ornamented by grooves parallel with the outer margin.

Locality and Horizon.—This specimen was obtained in the Culm beds of Hestow Farm, near Ideford, Devonshire.

Remarks.—*Phillipsia minor* has been described by Dr. Woodward from the Lower Culm of Waddon Barton (23, p. 68, pl. x, figs. 5, 6*a*, *b*, 7, 8*a*), and Hannaford Quarry, near Barnstaple (8*a*, p. 646, pl. xxviii, fig. 2).

PHILLIPSIA cf. MINOR, H. Woodward. Pl. VII, Figs. 12, 13.

Description.—The *cephalon* is parabolic in contour, and possesses a roughly oval-shaped tumid *glabella*, with sub-parallel lateral borders

and rounded anterior margin. Two well-marked basal lobes are present, and minute tubercles adorn the surface especially near the base. A pre-ocular pore is seen on the left margin near the frontal border. The well-developed marginal border of the head-shield is ornamented with narrow, curved furrows approximating in direction to that of the outer margin, while the genal extremity is produced into a prominent, slightly curved spine. The *eyes* are not preserved.

A portion of the *thorax* is present, and shows four rings of the rounded and elevated axis, which is bounded by well-marked furrows and is approximately equal in width to the lateral pleural area. The broad pleura are grooved down the centre and curve slightly backwards. Numerous minute tubercles ornament the whole surface.

The *pygidium* is 4 mm. long and about 5 mm. broad, and has a convex, very gradually tapering axis with about thirteen segments. The lateral pleural area is tumid and possesses at least eight segments, which curve very slightly backwards. Indications of a faint marginal bifurcation are present in some of the rings. Both axis and pleural areas are adorned with minute tubercles. The fairly broad marginal border narrows slightly anteriorly, and is apparently without distinct ornamentation. Its extreme posterior extremity is somewhat angular.

Locality and Horizon.—The same as the preceding.

Remarks.—The preservation of the head-shield is imperfect, but judging from the parts of that region in good condition it could well be assigned to *Phillipsia minor*. Examination of the pygidium, which by its proximity and position in the hand-specimen undoubtedly belongs to the head, shows, however, that this determination would be doubtful. The pygidial axis of *Ph. minor* is considerably more tapering, while the marginal border of the same species is much more curved than in our form.

PHILLIPSIA sp. Pl. VII, Fig. 14.

Description.—A fairly well-preserved cast of a head fragment shows an elongated tumid *glabella* with sub-parallel lateral borders and a very rounded anterior extremity. The length of the glabella is 5·5 mm., and its greatest breadth 3 mm. The triangular basal lobes are well marked and bounded by a strong pair of lateral furrows. A second pair of furrows occur anteriorly to the latter. These are directed inwards and backwards, and gradually become shallower as they approach one another posteriorly. In this manner a second pair of elongated lobes are marked off and a V-shaped sculpture given to the glabella. Anteriorly to the second pair of furrows, and about half-way between them and the frontal extremity, is a small marginal pitting on either side corresponding to the pre-ocular pores. The frontal lobe is separated from the raised anterior termination of the head-shield by a shallow depression. The facial sutures cut the curved frontal border of the shield at a distance of about 6·5 mm. apart. They run at first slightly outwards, then turn backwards and inwards, and are again deflected slightly outwards at a short distance from the second pair of glabella lobes. From this point they curve inwards and backwards near the basal lobe, finally running in a shallow curve outwards and backwards, and

cutting the occipital ring at a low angle. The occipital ring is elevated and convex, and separated from the glabella by a deep furrow.

Locality and Horizon.—Same as the preceding.

Remarks.—This form appears to be quite distinct from any other known *Phillipsia* in the character of the second pair of glabella lobes. With more material it may have to be described as a new species.

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EXPLANATION OF PLATE VII.

FIG.

1. *Phacops* (*Trimerocephalus*) *anophthalmus*, Frech. Anterior margin slightly water-worn. Natural size. Daymer Bay. [23430.]
2. *Phacops* (*Trimerocephalus*) aff. *cryptophthalmus*, Emmr. (Gümbel's interpretation). × 3. Whiteway Farm. [22884.]
3. Enlarged view of the eye of the same. × 8.
4. *Phacops* (*Trimerocephalus*) *tripartitus*, sp. nov. × 3. Whiteway Farm. [22884.]
5. The same, somewhat compressed laterally. × 3. Whiteway Farm. [23431.]
6. *Proetus dunhevidensis*, sp. nov. × 2. Old quarry near Landlake, South Petherwin. Original is in the Southgate Museum, Launceston.
7. *Proetus*, sp. *a*. × 2. Whiteway Farm. [23432.]
8. *Proetus*, sp. *b*. × 3. Whiteway Farm. [22884.]
9. *Proetus*, sp. *c*. × 2. Whiteway Farm. [23433.]
10. *Dechenella ussheri*, sp. nov. × 3. Whiteway Farm. [22884.]
11. *Phillipsia minor*, H. Woodward. × 3. Hestow Farm. [23434.]
12. *Phillipsia* cf. *minor*, H. Woodward. × 3. Showing the glabella and ornamented border of head-shield. Hestow Farm. [23435.]
13. The same. × 2. Showing the pygidium and drawn from a wax cast of an impression. [23434.]
14. *Phillipsia* sp. × 2. Showing the well-sculptured glabella. Hestow Farm. [23436.]

The originals, unless otherwise stated, are in the Geological Survey Collection. The register numbers are given in brackets.

II.—Some Remarks on the Mechanics of Overthrusts.

By M. S. Smoluchowski, Ph.D., LL.D., Professor of Physics at the University of Lemberg, Austria.

MR. T. MELLARD READE evidently wished to elicit, by his note on the mechanics of overthrusts in the Geological Magazine, 1908, p. 518, a discussion on these phenomena, as he also tells us in the February Number, 1909, p. 75. May I be allowed, therefore, to contribute some remarks on his paper?

It is easy enough to calculate the force required to put a block of stone in sliding motion on a plane bed, even if its length and breadth be 100 miles, and I do not think Mr. Mellard Reade meant to use the word 'incalculable' in a literal sense. However great this force may be, it certainly will be easy to mention instances of still greater terrestrial or cosmic forces. Still, I think Mr. Mellard Reade might dispute the analogy with the piling up of the Rev. O. Fisher's broken ice-sheets, and he could defend his statement "that no force applied in any of the mechanical ways known to us in Nature would move such a mass".[1]

Let us indicate the length, breadth, and height of the block by a, b, c, its weight per unit volume by w, the coefficient of sliding friction by e; then, according to well-known physical laws, a force a, b, e, w, e will be necessary to overcome the friction and to put the block into motion. Now, the pressure exerted by this force would be distributed over the cross-section a, e; hence the pressure on unit area will be equal to the weight of a column of a height b, e. Putting $e = 0{\cdot}15$ (friction of iron on iron), $b = 100$ miles, we get a height of 15 miles, while the breaking stress of granite corresponds to a height of only about 2 miles. Thus we may press the block with whatever force we like;

[1] T. Mellard Reade, Geol. Mag., November, 1908, p. 518.

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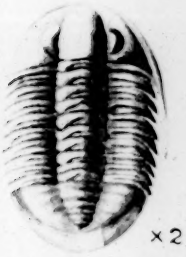

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H. H. Thomas del.

Trilobites from Devon and Cornwall.

we may eventually crush it, but we cannot succeed in moving it. The conclusion is quite striking, and so far we cannot but agree with Mr. Reade's opinion.

But are we entitled, therefore, to condemn the theory of the Alpine overthrusts? I think the comparison is not quite fair. First, it may be remarked, the bed may not be horizontal but inclined; in this case the component of gravity is sufficient, at an inclination of 1 : 6·5, to put the block in sliding motion, and we need not apply any external pressure at all. And what seems still more important, nobody ever will explain Alpine overthrusts in any other way than as a phenomenon of rock-plasticity. Suppose a layer of plastic material, say pitch, interposed between the block and the underlying bed; or suppose the bed to be composed of such material: then the law of viscous liquid friction will come into play, instead of the friction of solids: therefore any force, however small, will succeed in moving the block. Its velocity may be small if the plasticity is small, but in geology we have plenty of time; there is no hurry.

Some features of these phenomena have been beautifully illustrated by Professor Sollas' pitch-experiments. Pitch is not the same as rock undoubtedly, a point which Professor Bonney lays much stress upon in the August Number, 1907, of the Quart. Journ. Geol. Soc., but, on the other side, let us realize the difference between two months (required for Professor Sollas' experiments) and hundreds of thousands or millions of years which must be allowed for the analogous process in the Alps. The analogy shows mountain-building to be a very slow, gradual process, in virtue of the smallness of plasticity, but it would be in the main a continuous process, and I do not think we are forced to assume its discontinuity, as Mr. Mellard Reade seems inclined to do.

The plasticity of rocks in greater depths is to be explained partly by elevation of temperature, partly by pressure. But whatever explanation we accept, there are too many evidences to deny the fact.

In conclusion, we must say Mr. Mellard Reade's paper is very instructive; indeed, it helps us to see, by contrast with the author's ideal example, what are the most essential features of the process as displayed in Nature.

III.—A Crinoid (*Tetracrinus* [?] *felix*, n.sp.) from the Red Crag.

By F. A. Bather, M.A., D.Sc., F.G.S., etc.

(PLATE VIII.)

MR. P. G. H. BOSWELL, F.G.S., has kindly submitted to me a crinoid fragment found by him on August 20, 1908, in the Red Crag of Felixstowe cliffs, Suffolk. Although the specimen is somewhat obscure, it is of sufficient interest to warrant a brief note.

"The exact position of the place," writes Mr. Boswell, "was half-a-mile east of Felixstowe Church (Newbournian Zone of Red Crag). In the course of eight years' acquaintance with the Crags, having sifted for three years, I have not met with any other specimen of a crinoid, but Mr. F. W. Harmer, F.G.S., tells me he has met with

several worn specimens of *Pentacrinus* during his Oakley (Waltonian Zone, Red Crag) sifting. These he believes to be derivative in the Crag. I agree with him and with Dr. Bather in thinking this new specimen to be probably derivative also."

In all British Tertiary rocks crinoids are rare, some four or five species being known from the London Clay, but none from any of the later rocks. The Red Crag is one of the last formations in which one would expect to find a stalked crinoid, but it is of course probable that the fossil is derived from some older rock. The specimen is further interesting from the fact that it does not appear to agree with the remains of any species (one might almost say any genus) hitherto described, whether from rocks of corresponding Middle Pliocene age in other parts of the world, from Tertiary rocks in general, or from those Cretaceous rocks whence it may have been derived.

The fossil, which at first sight looks like a single columnal, appears on closer examination to comprise remains of the cup. Unfortunately its upper half is somewhat worn; the sides also are disfigured, both in the upper and lower half, by a few pittings, probably due to some boring organism; and the whole is covered with the glaze or patina so common in Red Crag fossils.

The shape is roughly that of a squat, swollen barrel, the upper and lower ends being approximately circular, though not quite parallel. The greatest height is 5·5 mm.; greatest equatorial diameter, 6·9 mm.; least equatorial diameter, 6·75 mm.; diameter of the articular face at the lower end, about 4·4 mm. The upper half is separated from the lower by a slight step (not a distinct ridge) approximately corresponding with the equator, but with five slight equal curves, concave towards the worn face. Apart from this feature, which may be largely the result of weathering, the curvature of the sides is equable and their surface is smooth, except for some almost imperceptible traces of pustules, more visible on the less worn half.

More obvious pustules surround the articular face of the lower half, and seem to form an obscurely pentagonal border, having the angles of the pentagon corresponding with the cusps between the curves of the step already mentioned. The pustules are unequal in size, and the larger ones tend to be situate at the angles, an arrangement that enhances the pentagonal appearance. Within this border the articular face is concave, rising again slightly towards the centre so as to form a faint swelling round the axial canal. This canal has so irregular an outline that one cannot say whether it was slightly pentagonal, or elliptical, or merely circular. In any case there is no trace of a fulcral ridge. The greatest diameter of the axial canal is, very roughly, about 1 mm. (Fig. 3).

The five curves of the equatorial step or rebate were intensified by iron staining, but on washing this away, there became visible traces of sutures following the curves. These were more clearly seen with the aid of glycerine and alcohol, and traces of vertical sutures could also be detected rising upwards from the cusps. These sutures are very difficult to see, but they are enough to show that the upper half of this fossil consists of five elements, and this affords the only rational explanation of the peculiar weathering. These elements must have

been closely anchylosed to one another and to the lower undivided half of the fossil (Fig. 2).

The upper face of the fossil, so far as its worn condition enables one to judge, is flat towards the margin, but slightly excavate towards the centre, not so excavate as the lower end. The actual centre is occupied by an axial canal, the borders of which appear to bear some radiating grooves; but these and the other markings of this face are so obscure that it is safer to attempt no description. If vertical lines be drawn upwards from the cusps, in the position of the traces of the vertical sutures, those lines seem in three or four cases to end in slight pustules or elevations. At the boundary of this face there are, however, three or four larger prominences, each coinciding with the middle of one of the five elements (Fig. 1).

The structures described have now to be interpreted. The five elements of the upper half cannot well be anything but basals or radials. That they are radials seems to result from the following considerations. Had they been basals, they would have shown some traces of a hexagonal outline, whereas they are pentagonal with flattened upper surfaces. Their size is more consistent with their being radials, since there is a tendency to the reduction of basals in all crinoids of Tertiary and later age.

If we accept the five upper elements as radials, we have to enquire what has happened to the basals. Are they fused into the single element forming the lower half of the fossil, or have they been overgrown by the radials and included in the interior of the cup, or have they possibly atrophied out of existence? I am inclined to adopt the first of these three explanations. The question may be put in another way: is the lower half of the fossil a proximale (i.e. a persistent top columnal), or is it a fused basal circlet? Now a proximale, while it has a modified upper face, for the reception of the elements it supports, generally has a lower face like the articular faces of the succeeding columnals. In the present instance those columnals are not known to us; but we do know enough about crinoids in general to be aware that a joint-face with a smooth regular concavity rarely has a pentagonal border of pustules. This pentagonal border is more readily explained as the last trace of the original pentamerism of the fused basal circlet.

Taking then, as a working hypothesis, the view that this fossil consists of a fused basal circlet supporting five closely united radials, we have to consider its systematic position.

Of the six families of recent crinoids recognized in the *Treatise on Zoology* (vol. iii, London, 1900), the Pentacrinidæ may at once be set aside by reason of their stem-articulation.

The Bourguetierinidæ occasionally have columnals that recall the massive appearance and outline of this fossil; but in such forms the joint-face of the proximal columnals always has a distinct fulcral ridge, and the basals are distinct. The Upper Cretaceous *Mesocrinus* might otherwise have been thought to show some resemblance. *Rhizocrinus*, which still lives in the North Atlantic, is the only genus of the family recorded from Tertiary rocks, but bears no great likeness to this fossil.

The Holopodidæ, with their ancestors the Eugeniacrinidæ, have a similar massive structure, but had at an earlier period proceeded further in the union of the radials and inclusion of the basals within them.

The Apiocrinidæ, which are represented in modern seas by *Calamocrinus* of the Central Pacific, and in the Cretaceous of Europe by *Acrochordocrinus*, might possibly receive this fossil; but the joint-faces of the columnals are marked by radiating striæ or by tubercles, and there is no known genus that shows any close resemblance.

The Bathycrinidæ include only the deep-sea form *Bathycrinus*, a genus which in its possession of a fused basal circlet, followed by discoidal columnals, might seem fitted to receive our fossil. In this genus, however, the radials are very easily separated from the base.

The Hyocrinidæ are also deep-sea forms, namely, *Hyocrinus*, *Gephyrocrinus*, and probably *Ptilocrinus*. No fossil representatives are yet known, but I agree with Professor Jaekel that they are probably descended from the Plicatocrinidæ of Jurassic age. It is somewhere in this series that I incline to place our fossil. In the Plicatocrinidæ and in *Gephyrocrinus* and *Ptilocrinus* the basals are fused. The last two genera have the slender habit characteristic of deep-sea crinoids, but among the Plicatocrinidæ *Tetracrinus* has the massive habit found in crinoids that occupy a more exposed position—the reef-type of Jaekel. The pustular ornament and doliform shape of our specimen are very reminiscent of *Tetracrinus*. Remains of the ornament are seen in *Gephyrocrinus Grimaldii*, Koehler & Bather (1902, figs. 1, 2), as a ring of a dozen small conical tubercles at the proximal margin of the base, projecting beyond the joint-face. Slighter traces are also found in *Ptilocrinus antarcticus*, Bather (1908). In *Gephyrocrinus* and *Tetracrinus* the joint-face of the columnals is plane, with slight radiating grooves at the periphery; where new columnals are arising, as next the base, the adjacent joint-faces would naturally be more concave.

On the whole, then, I would suggest that this Red Crag fossil represents the patina (RR and BB) of a shallow-water Crinoid, connecting the Plicatocrinidæ with the Hyocrinidæ. It does not quite agree with any of the known genera, and in the absence of further evidence it is hard to say which of them is most closely allied. Among living forms it is perhaps nearest to *Gephyrocrinus*, but it would be absurd to suppose that it had the peculiar character of the subvective grooves that distinguish that genus, since that character is clearly connected with the deep-sea habitat. On the other hand, it is probably a long way from *Tetracrinus* in the geological scale, and its superficial resemblance is largely due no doubt to similarity of habitat. Very likely it represents an undescribed genus; but I cannot bring myself to base a new generic division and name on so obscure a specimen. Let it be enough for the present to establish a new species, which may provisionally, and as a mere matter of convenience, be referred to *Tetracrinus*.

Tetracrinus (?) *felix*, n.sp.

Diagnosis.—A *Tetracrinus* (?) with doliform patina; RR closely united to each other and to the basal circlet; proximal border of base

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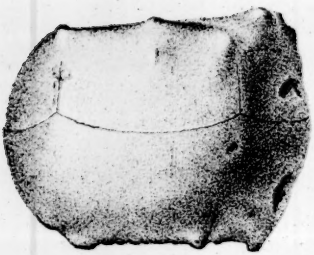

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A. H. Searle del.

TETRACRINUS (?) FELIX, sp. nov.

projecting beyond stem-facet and ornamented with small pustules forming a pentagon; traces of similar ornament on RR, especially a perradial prominence at the distal border of each.

Holotype.—The unique specimen collected by Mr. P. G. H. Boswell.

Horizon.—Newbournian zone of Red Crag (Middle Pliocene), probably derived.

Locality.—Felixstowe, Suffolk.

EXPLANATION OF PLATE VIII.

Fig. 1.—View of the holotype from above.
,, 2.—Side view of the holotype.
,, 3.—View of the holotype from below, showing stem-faces.

All figures are enlarged six diameters, and in each the right and left sides remain in the same position with regard to the beholder. Drawn by Mr. A. H. Searle.

Postscript.

Mr. F. W. Harmer, F.G.S., has kindly sent me five other fragments collected by him in the Red Crag, and presumed to be of crinoid origin.

One of these is shaped like the tapering end of a belemnite, and I can detect in it no crinoid structure. The outer crust is silica in the form of beekite; the interior, exposed at the broad, broken end, is ferruginous (? limonite) with traces of calcite.

Another is a cylindrical fragment, 6·2 by 4·8 mm., much worn, with a beekite crust, and traces of radiate striæ in the interior. If echinodermal, it might be the proximal end of an echinoid radiole or part of a crinoid stem.

Two specimens are certainly parts of Pentacrinid stems. One is 30·9 by about 5 mm., rather less in diameter at one end and swelling suddenly to a maximum of 6 mm. at the other end, which is rounded. The joint-face is not preserved; the side-faces are smooth; on the sutures are slight indentations, radial in position. This orientation is proved by the weathering of the thinner end of the fragment, where the interradial ligamentar areas have been eaten into owing to their less density. There is no trace of a cirriferous nodal. There can be scarcely any doubt that this is part of the stem of *Balanocrinus subbasaltiformis*,[1] and that it has been derived from the London Clay. The other Pentacrinid stem-fragment probably belongs to the same species; it is rounded off rather acutely at one end; at the other is an apparent hypozygal with slight traces of the markings on the joint-face. The substance of these specimens is apparently limonite, probably altered from a previous pyritized stage.

The remaining fragment is cylindrical, 11·8 mm. long, 5·3 mm. in diameter at one end, tapering to 4·6 mm. at the other end, which is more worn. The outer surface of the side-faces has been altered by partial change into beekite, so that no sutures are visible. The joint-face at the wider end is obscure, but shows some straight striæ radiating from the lumen; here are still traces of calcite. The narrower end is eaten into, and the lumen widened; this enables one to see that the fragment is composed of thin columnals, about ·5 mm.

[1] *Pentacrinus subbasaltiformis*, J. de C. Sowerby, *ex* J. S. Miller nom. nud., in N. T. Wetherell, 1840.

high, with a radiate micro-structure, and a radiately striate joint-face producing finely crenulate sutures.

I am not acquainted with any similar stem from either the Chalk or the Lower Tertiaries; but that crinoids having such a stem must have existed during those periods is rendered highly probable by the fact that this is a usual form of stem in the Jurassic Apiocrinidæ, and that we still find it in their modern representative *Calamocrinus* as well as in the Hyocrinidæ. The discovery of this fragment, imperfect though it be, leads one to expect that the missing links will ultimately be found in their correct stratigraphical position.

It is not probable that any of these crinoid fragments, the results of Mr. Harmer's long years of collecting, are related to *Tetracrinus felix*. Their sole importance in this connection lies in their bearing on the age of the derived crinoid fragments found in the Red Crag. The only direct evidence is that of *Balanocrinus subbasaltiformis*, which is common in the London Clay, and probably had a wide range, since a variety of it (var. *Pratti*) is common at Biarritz. Specimens in the British Museum [75,838] were found at Harwich. In the London Clay the substance of this fossil, as of the other echinoderms, is generally changed into iron pyrites or marcasite; and this is consistent with the present condition of Mr. Harmer's Red Crag specimens. They, however, differ in this respect from Mr. Harmer's other specimens, which agree among themselves in having a beekite crust. The silicification no doubt took place before they were redeposited in the Crag, and, taken in conjunction with the possible belemnite nature of one, it suggests the Upper Chalk as their parent rock. However this may be, no inference can be drawn as regards *Tetracrinus felix*, which retains its original calcite composition, pure and unsilicified.

IV.—Extinct Marsupials of Western Australia.

By Bernard H. Woodward, F.G.S., C.M.Z.S., Director of the Western Australian Museum.

BEFORE the beginning of this year the only records of the occurrence of fossil marsupials in Western Australia consisted of the account of the discovery of Diprotodon bones in the Kimberley district by Mr. E. T. Hardman, the Government Geologist, in 1882, and the finding of a lower jaw of this animal in 1895 in a gully near Lake Darlot in the Eastern Goldfields by Mr. Arthur, who presented it to this Institution. This jaw was so much weathered that it was valueless except for the fact of its establishing the existence of that marsupial so far inland. The Museum Committee sent an expedition to Lake Darlot in 1898, and in 1908 the Hon. Dr. Hackett sent out at his own cost Mr. Young, who was with Mr. Arthur when he found the jaw in 1895. Both these parties were unsuccessful.

In February, 1909, Mr. John Sharp, of Balladonia, Point Malcolm, on the south coast, sent to the museum a number of bones and a few teeth of *Diprotodon australis* that he had unearthed when excavating for water in a marsh on his station. These specimens

are much weathered. Mr. Sharp has kindly promised to send further specimens next summer, as excavation cannot be carried on during the winter owing to the boggy nature of the ground. It may help to explain the difficulty of conducting research in this vast country when it is stated that it took more than three months for the bones to reach the museum after they were sent from Balladonia by waggon to catch the steamer at Esperance for Fremantle, thence to be conveyed by rail to Perth. Except in the closely settled districts the means of travel are difficult, slow, and costly.

The most interesting discoveries, however, are those made by Mr. Glauert during the past two months, which have resulted in the collection of about 2,000 bones and fragments of bones in the Mammoth Cave, Margaret River, about 200 miles south of Perth. These include *Diprotodon*, a new species of *Sthenurus*, and probably *Nototherium* and *Phascolonus*, associated with many specimens of wallabies still living, e.g. *Macropus brachyurus*, etc.

This proves that *Diprotodon* can only have become extinct in quite recent times.

The Mammoth Cave is one of the numerous beautiful stalactitic caves occurring in the Coastal Limestone, a group of shelly limestones and sandstones of Pleistocene age, which is found all along the western coast from Cape Leeuwin in the south-west to North-West Cape. The limestone extends in width from a few miles to 30 or 35 miles. Many of the caves which occur along this belt have been opened to the public under the management of the Caves Board. In 1904 Mr. T. Connolly, the caretaker, in cutting a pathway in the Mammoth Cave under the direction of Mr. Edgar Robinson, the superintendent of the caves, came across some fossil bones and called the attention of a visitor to them. This gentleman retained the bones for five years without publishing any description of them, and then handed them back to the Caves Board, who placed them in Mr. Glauert's hands for examination. He determined them to be a new species of *Sthenurus*, which he proposes to name *S. occidentalis*.

As long ago as August, 1905, the writer was invited by the Hon. Dr. Hackett, the chairman of the Caves Board, to accompany him to the Margaret River Caves in order to select sites for exploration, and it is at the spot then selected as the most promising that this large number of bones were found. After a lapse of three and a half years the Museum Committee were so fortunate as to secure the services of Mr. Ludwig Glauert, F.G.S., the palæontologist to the Geological Survey.

A full account of these remains shall be forwarded as soon as they are classified.

A few words with regard to the living marsupials of Western Australia may be of interest, as during my residence of nearly twenty years in this State I have succeeded in obtaining several new species, raising the number known to fifty-two, but during this period many of these forms have become nearly, if not altogether, extinct. Everywhere with the advent of civilization the indigenous fauna disappears.

Our Natural History Society induced the Government in 1894 to set aside a reserve for the preservation of the indigenous fauna and flora, containing some 25 square miles in the Darling Ranges, but this was cancelled early last year. However, Barrow Island was gazetted for this purpose in November last. It is situated about 60 miles off the north-west coast, and is about 14 miles in length with an average width of 4 miles. It is the home of four species of mammals and one bird (*Malurus edouardi*) not found on the mainland. Bernier and Dorre Islands on the north-west coast are doomed now that the Government has set aside those islands as hospitals for sick aboriginals. Vigorous efforts are being made to induce our Government to follow the enlightened policy of that of the U.S.A., otherwise the majority of the marsupials will soon become as extinct as the dodo and great auk.

V.—The Constitution of the Igneous Rocks.

By F. P. Mennell, F.G.S.

In a paper read at the 1903 meeting of the British Association and afterwards published in this Magazine,[1] the method of calculating the chemical constitution of the igneous rocks by the collation of analyses was criticized, and the results were compared with those based on actual field-work in an area where such rocks were very abundant. Mr. F. W. Clarke, whose results and those of Mr. Harker[2] had interested me in the problem, has recently published a fresh calculation of the results of the rock analyses made in the Laboratory of the United States Geological Survey. It is not proposed to discuss these results in detail, and it will suffice for my present purpose to take the question of silica percentage alone. Mr. Clarke's average for all the 1,558 rocks analyzed up to the end of 1903 works out at 60·91.[3] Mr. Clarke, however, admits that the 'salic' rocks are more abundant than the other classes,[4] and he further grants that my criticism of his previous results is entitled to some weight, though he thinks that a wider range of observation would probably modify my opinion that granite is practically the average igneous rock.

I have already insisted on the fact that to obtain trustworthy data calculations must be based on areas where plutonic rocks are abundantly exposed. It is absurd, for example, to give flows of basalt covering the surface to a limited depth the same weight in our estimates as granite masses which extend indefinitely downward. Yet this is the result to which the collation of analyses leads us. Indeed, it goes much further, for the composition of the great granite masses is so readily ascertained upon mere inspection of microscope sections, or even of hand-specimens, that they are rarely analyzed at all unless they show exceptional features. And in getting at reliable averages it is just these exceptional features that we must avoid. It is easy to

[1] Geol. Mag., 1904, Dec. V, Vol. I, pp. 263–4.
[2] Geol. Mag., 1899, Dec. IV, Vol. VI, pp. 220–2.
[3] Data of Geo. Chemistry, Bull. 330, U.S. Geol. Surv., 1908, p. 26.
[4] Loc. cit., p. 25.

show how largely exceptional types are represented by analytical data among rocks of all classes. No one is likely to dispute the enormous preponderance of felspathic rocks over those containing the so-called felspathoids, yet if we were to measure their abundance by the number of analyses that have been made we should arrive at a very different conclusion. But this is precisely the method we are asked to accept as correct. I do not know what would be thought of a mining engineer who took all his samples of a gold reef from the points where he thought it likely he would get exceptional results, and then calculated the average value on such a basis, especially if he left out of account the widths which his samples represented.

In my former paper I only gave the data from a very limited area mapped in Rhodesia, and though this is representative of the conditions throughout the whole country, it may be well to give the results arrived at from the mapping of an area ten times as great in central Matabeleland. Of 20,000 square miles, approximately 2,340 are sandstone, 5,700 Archæan schists, etc., and 11,960 granite and other igneous rocks. These last comprise portions of a number of plutonic masses, among which are two developments of syenite with about 63 per cent. of silica, covering some 40 square miles. There is also an important intrusion of a pyroxenic rock, which may be regarded as largely picrite and as containing on an average 45 per cent. of silica. It is probably a gently inclined sheet injected along a thrust plane, and its outcrop is much wider therefore than its true thickness. I have, however, taken the apparent width as the real one in order not to unduly favour my argument. Nearly all the rest of the igneous area is granite, with an average silica percentage of at least 70. It must not be thought that there are few basic rocks; on the contrary, they are well represented by dolerite dykes, basalt flows, etc. We shall nevertheless be making a generous allowance for them if we suppose there are 10,000 dykes a mile long and 5 feet thick, and 100 square miles of basalt 20 feet thick. We may further assume that they contain about 50 per cent. of silica. The volume of the dolerites may be subtracted from that of the granites, in which they are commonly intrusive. The basalts are intercalated among the sandstones that have been referred to.

Not to make too great an assumption regarding what may happen at a depth, we will suppose that each dyke and plutonic mass has vertical boundaries (though we have evidence that the latter class tends to spread out and encroach on the schists below the surface). We may then calculate the bulk of the various classes down to sea-level (i.e., nearly 5,000 feet, or, say, roughly, 1 mile) as follows:—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite	70	11,670	1 mile	11,670
Syenite	63	40	,,	240
Picrite, etc.	45	240	,,	40
Dolerite, etc.	50	nearly 10	,,	10
Basalt	50	100	20 feet	
			Total	11,960

To obtain a true average we now multiply each silica percentage by the volume of the rock represented, the products being added up and divided by the total volume. The result is a silica percentage of 69·45 for the whole. Whatever composition is assigned to the granites, their percentage will, in fact, be very near the general average, which, it will be noticed, is much higher than Clarke's figure. Granite, indeed, as previously pointed out, is not one extreme of the igneous series, but is substantially the average igneous rock.

In order not to lay too much stress on observations made in a single area, I have made similar calculations with regard to others of which I happen to have reliable data. England would evidently give very much the same result, but I do not possess a map which discriminates between the various classes of igneous rock with sufficient accuracy.

There are, however, no large masses of basic rock to set off against the granites of Cornwall, Devonshire, Cumberland, and Leicestershire. The Scottish Highlands would be an excellent area from which to draw conclusions, and it is evident that the granite masses are numerous and large as compared with other classes. My own native colony of Victoria (Australia) is perhaps not altogether typical, as the exposures of igneous rocks are much smaller than those of the sediments, and the southern portion is largely covered by flows of tertiary basalt. However, taking an area of twenty thousand square miles north of latitude 37°, i.e. between Maldon, Mansfield, and Omeo and the New South Wales border, the following rough estimate may be made regarding the 2,810 square miles of igneous rocks exposed:—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite	70	2,440	1 mile	2,440
Basalt	50	100	250 feet	5
Other classes	55	270	1 mile	270
			Total	2,715

In this case the silica percentage works out at 68·4. Canada is a country where the great development of igneous rocks makes the results as interesting as in the case of Tropical Africa, and I have therefore roughly worked out the data afforded by the West Kootenay (British Columbia) sheet of the Canadian Geological Survey map. Its southern boundary is the United States border, while to the north I have stopped a few miles short of the margin of the sheet at 50° N. lat. in order to avoid inconvenient calculations. The area dealt with is in round figures 5,500 square miles, of which about 4,260 show igneous rocks. Among the rocks mapped as metamorphic there are granites, but they are not coloured separately, and are therefore left out of calculation. Of the others there are three types of granite which may be grouped together as averaging 70 per cent. of silica all through. There are also three series of volcanic rocks which appear from the descriptive notes appended to the map to be in each case mainly andesitic in character. There are also exposures of serpentine, and of a 'monzonite' stated to be related to the gabbros. Tabulating these as before, we have, to a depth of a mile—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite	70	3,560	1 mile	3,560
Monzonite	50	20	,,	20
Serpentine	40	5	,,	5
Andesite, etc.	55	680	1,000 feet	130
			Total	3,715

On this basis the silica average is 69·3 per cent., almost exactly what is calculated for Rhodesia. Whether this is typical of Canada generally I cannot say, but since one reads of granite masses a thousand miles in length, it is probable that the silica percentage is not too high.

These observations may be reinforced by another line of argument. Mr. Clarke calculates the amount of quartz present in the igneous rocks as averaging 12 per cent. of the whole.[1] He also gives estimates of the average composition of the sediments, in this case, however, making an assumption as to the relative abundance of each class, and merely giving composite analyses to obtain the composition of each division taken separately. His figures for silica are: shales, 58·1 per cent.; sandstones, 78·3 per cent.; limestones, 5·19 per cent. For quartz as apart from combined silica he gives: sandstones, 66·8 per cent., and shales, 22·3, which are certainly not excessive estimates. Now let us take Van Hise's assumption that, of the sediments, 65 per cent. are shales, 30 per cent. sandstones, and 5 per cent. limestones.[2] On this basis, even assuming that the limestones contain none, they should average over 34 per cent. of the mineral. Clarke himself assumes that the sediments comprise 80 per cent. of shales, 15 per cent. of sandstones, and 5 per cent. of limestones. His figure for the shales appears altogether excessive, and as the proportions he adopts are chiefly based on his own calculations regarding the igneous rocks, we should be merely reasoning in a circle if we accepted them. On the basis of collating analysis, which he adopts for the igneous series, the figures would be very different. Now there is only one source for the sediments: they must all have been derived directly or indirectly from igneous rocks, and if the latter only contained 12 per cent. of quartz, as calculated by Clarke, how could the former contain 34 per cent.? No allowance for secondary quartz can overcome this difficulty, for the obviously detrital quartz of the sandstones alone amounts to 20 per cent. of the whole bulk of all the classes of sediment taken together. There is also another consideration which shows that Clarke's igneous average allows far too much weight to the basic division, namely, the great deficiency of magnesia in the sediments. On his estimate they should contain over 4 per cent., whereas they actually contain less than 2½ on the most favourable assumptions. The amount of potash also evidences the same tendency.

In conclusion, I should like to pay a tribute to the value of the work of which I have ventured to criticize one of the details. Mr. Clarke's recently published volume should be of great service to geologists

[1] Loc. supra cit., p. 30.
[2] Treatise on Metamorphism: Mon. U.S.G.S., 1904, p. 940.

generally, and it is a matter for regret that the geological surveys of most other countries are so far behind that on behalf of which so much valuable material has been brought together.

VI.—The Microsauria, Ancestors of the Reptilia.

By Roy L. Moodie, the University of Kansas.

ONE of the most interesting and most vexed questions in vertebrate palæontology at the present day is the one which concerns the origin and development of the reptiles. The progress of research has shown the Reptilia to be a wonderfully diverse class, and nearly thirty orders of animals have been assigned to the group. With all this diversity of structure there is, of course, associated a great diversity of habit. We know all kinds of extinct reptiles from the semi-aquatic to the aquatic, from the flying to the fossorial, from the arboreal to the subterranean, and many are the varying degrees of structure which are associated with these various habits of life.

Recent investigations into the anatomy of the Carboniferous Microsauria of North America have led the writer to the conclusion that the Microsauria could easily have been the ancestors of all the later reptiles. The idea that the Microsauria stood ancestrally to the Reptilia is not at all new. Gadow expressed it very clearly when he placed the Microsaurians in the Prosauria. Boulenger has expressed his opinion as to this idea. Baur and others have all agreed that the Microsauria stood ancestrally to some of the reptiles, but no one has, so far as I know, claimed that they might be the ancestors of all the class. It shall be the purpose of this essay to point out briefly the main anatomical features of the Microsauria, and to show in what way they may be homologized with the structures exhibited by the reptiles. A more extended discussion of this matter and a more detailed account of the anatomy of the Microsauria are to be contained in a work to be shortly published on the Carboniferous Amphibia of North America.

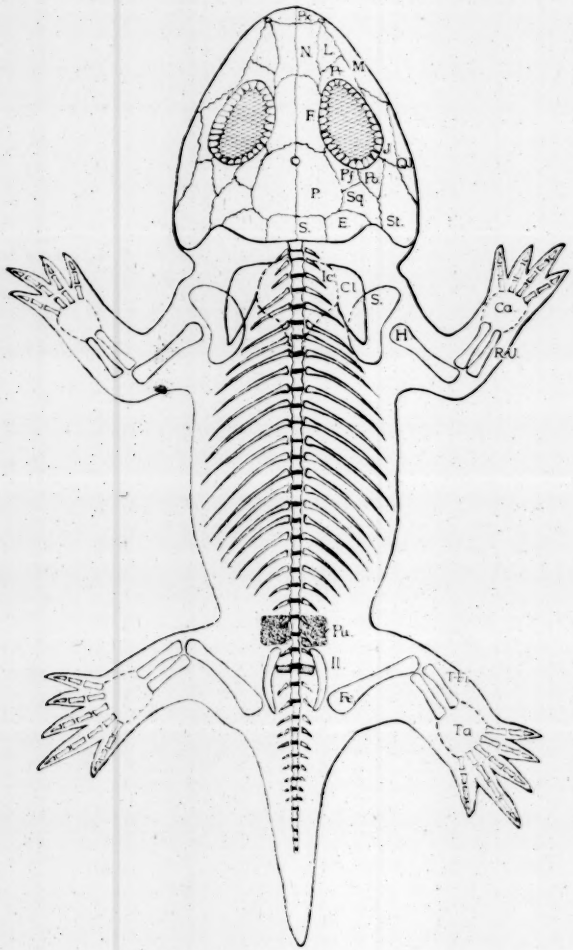
It has been now a little more than half a century since the first Microsaurian was discovered and described, and during that time the additions to our knowledge of these forms have been many. Cope and Dawson have described the Microsaurian fauna of North America, Fritsch has investigated very closely the fauna of Bohemia, Huxley has given us the history of the forms from the British Isles, and Credner has studied the forms from Saxony. Taken as a whole the literature on the group is extensive though not of a monumental character. Excepting for the works of Fritsch and Credner the publications in regard to the Microsauria are widely scattered and difficult of access, some of the works having been published privately.

The Microsauria may be defined as reptile-like amphibians with limbs well developed; usually longicaudate; skull bones sometimes sculptured with pits and grooves which not infrequently take the form of lateral line canals called 'slime grooves'; skull with horns on the epiotic, supratemporal, or without horns; branchia never persistent, if present at all; sclerotic plates present; vertebræ

phyllospondylous; ribs long and curved, always intercentral; usually single-headed, although there is at times an enlargement as though an incipient bicipital condition were present; sacral ribs single; dorsal vertebral series variable; tail sometimes containing over seventy-five vertebræ, the distal ones composed of the two pleurocentra; pectoral girdle invariably, in the American forms, composed of interclavicle, clavicles, and scapulæ. There is no evidence of a cleithrum in the forms from North America; pelvic girdle composed of an osseous ilium and ischium, pubis cartilaginous, sometimes calcified; articular surfaces of the limb bones well formed; carpus and tarsus cartilaginous; digits four in the hand and five in the foot; phalangeal formula 2–2–3–2 and 2–2–3–4–3; abdomen usually covered with an armature of scales, scutes, or rods; overlapping or rounded scales sometimes present over the entire body; skull stegocrotaphous with pineal foramen invariably present; supra-occipital plate and epiotics well developed. The palate so far as known has the pterygoids approximate, but the evidence is unsatisfactory. Only a fractured portion of a skull presents the palate for study. According to Jaekel the pterygoids are separated by the parasphenoid. It is unfortunate that more is not known of the palate, but the skulls are almost always preserved on their ventral surface, and only by preparation such as Jaekel has employed is it possible to obtain satisfaction as to the palatal condition. Material is not yet sufficiently abundant to admit of this.

In size the Microsauria show a wide range of structure. The known forms range from the minute *Odonterpeton triangularis*, Moodie, with a skull only 6½ millimetres in length, to *Macrerpeton huxleyi*, Cope, or *Eosaurus acadianus*, Marsh, which undoubtedly attained a length of many feet. The skull bones may be smooth or sculptured. The ribs may be long and slender or short and thick, but always curved. The limbs may be powerful or weak. If the Aistopoda are degenerate Microsaurians, as appears probable, the limbs may be entirely absent. The tail may be very short or very long with the vertebræ laterally flattened, proving the aquatic habit of the animal. The ungual phalanges are either sharp or blunt. The form is undoubtedly lizard-like, as is proven by the impressions of the bodies. The neck is very short, the pectoral girdle being closely attached to the head, but I have never seen an indication of the piscian union of pectoral girdle and skull. The body may be long and slender or short and thick. In short, there are a great variety of shapes and forms associated with a multitude of anatomical structures, which give a vast range of possibilities for development. The group is widely heterogeneous.

The differences between the earliest known reptiles and the Microsauria, so far as known, are the possession by the reptiles of osseous carpus and tarsus and the two sacral vertebræ associated with a more highly developed condition of the limb bones. These differences are not at all insurmountable. Unfortunately the skulls of neither of the two best preserved Carboniferous reptiles, *Isodectes copei*, Williston, and *Sauravus costei*, Thevenin, are preserved. They were undoubtedly stegocrotaphous. It would be of the greatest



AMPHIBAMUS GRANDICEPS, Cope.

EXPLANATION OF FIGURE.

A restoration of *Amphibamus grandiceps*, Cope, from the Mazon Creek Beds, Carboniferous of Illinois. The restoration is based on a complete specimen of the species and on Cope's drawings. The form of the body is *not* conjectural.

Skull.—Px. premaxilla; N. nasal; F. frontal; P. parietal; So. supra-occipital; E. epiotic; L. lachrymal; Pr. prefrontal; Pf. postfrontal; Po. post-orbital; Sq. squamosal; M. maxilla; J. jugal; Qj. quadrato-jugal; St. supratemporal.

Skeleton.—Ic. interclavicle; Cl. clavicle; Sc. scapula; H. humerus; R-U. radius, ulna; Ca. carpus; Pu. pubis; Il. ilium; Fe. femur; T-Fi. tibia-fibula; Ta. tarsus.

interest to know the condition of the pterygoids in these forms. In the absence of these important structures we must base our conclusions on the structures present.

In both groups, then, we find the following structures identical:—Ribs intercentral, intercentra absent, vertebræ amphicœlous with notochord persistent, pectoral and pelvic elements identical, number of dorsal vertebræ agrees in some forms, limb bones with well-developed endochondrium which becomes more pronounced in the reptiles, phalanges clawed, hand and foot broad, neural spines of the vertebræ low, rudimentary, or absent.

The absence of intercentra in the Microsauria is assured. There is not the slightest evidence that the vertebral column is composed of other than the pleurocentra and neurocentra. The intercentra probably developed late in the history of the Amphibia as in the Temnospondylia, and were transmitted by some of the Amphibia to the reptiles. I cannot believe that the intercentra are inherited from the piscian ancestors.

The only tangible differences, then, on which to base a separation of the reptiles from the Microsauria is on the reduced parasphenoid, osseous carpus and tarsus, and two sacral vertebræ. These characters serve well as class distinctions, and we must await further knowledge to unite the earliest forms which we now call reptiles and the latest forms of the so-called Amphibia. It has been suggested that the Microsauria do not furnish forms which could have given rise to the broad-headed Cotylosauria and their allies. But members of the new genus *Erpetosaurus* bear very close resemblance to these forms. The skull is closely sculptured, broad, and heavy. The members of this group and its allies might well have stood in an ancestral position to the later forms.

The Microsauria as known, however, are confined to the land and marsh dwellers, and we know nothing as yet of the inhabitants of the open seas, if there were any. It is quite possible that some members of the group such as *Œstocephalus*, which was a good swimmer, took to the sea, and from some form like this was developed the Ichthyosaurs, Mesosaurs, and the other aquatic forms. One thing which tends to militate against the Microsauria is their small size; if, however, it is taken into account that not all the Microsauria were small but that it is only the small ones which are well known, this objection can have little weight. We shall undoubtedly some day know the other forms of which we have now only faint traces, and although we may not then call them Microsauria they may nevertheless serve to bridge the gap between the Amphibia and the Reptilia. The occurrence of *Isodectes*, so similar in form and structure to the Microsauria, in the same bed with them leads one to think that they were already an old race; and the diversity of their structure would substantiate this view.

There has been some tendency among recent authors on the Microsauria, including the present writer, to class them with the Reptilia. This may, in the future, be necessary, but not in the present condition of our knowledge. Dr. R. Broom in a letter to the writer expressed very good ideas on the scheme by which to divide the

reptiles and amphibians. He says: "I fancy it will be safest to keep as Amphibia the forms with two condyles, large presphenoid (vomer), and pterygoids wide apart." These characters, taken in connection with the condition of the carpus and tarsus, the sacral ribs, and the degree of ossification of the limb bones, will serve to keep the two classes separate.

In pursuance of the above scheme the following classification has been outlined for the Amphibia as we now know them, and will be used until further knowledge teaches otherwise. This scheme was read before the recent meeting of the Kansas Academy of Science.

Class AMPHIBIA, Linné, 1758. Devonian to Recent.
- Subclass I. Euamphibia, nom. nov. Carboniferous to Recent.
  - Order 1. Branchiosauria, Lydekker, 1889. Carboniferous and Permian.
  - Order 2. Apoda, Oppel, 1811 (Gymnophiona, Müller, 1832). ? Permian and Recent.
  - Order 3. Caudata, Dumeril, 1806. (? Permian) Jurassic to Recent.
    - Suborder 1. Proteida (Mudpuppies), Cope, 1868. Eocene to Recent.
    - Suborder 2. Meantes (Sirens), Linné, 1766. (In appendix to 12th ed. Syst. Nat.)
    - Suborder 3. Mutabilia (Salamanders), Merrem, 1820.
  - Order 4. Salientia, Laurenti, 1768. Eocene (? Jurassic, *Eobatrachus*) to Recent.
    - Suborder 1. Aglossa, Wiegmann, 1832.
    - Suborder 2. Linguata, Gravenhorst, 1845.
    - Suborder 3. Costata, Lataste, 1879.
- Subclass II. Holospondyli, Schwarz, 1908. Carboniferous.
  - Order 1. Microsauria, Dawson, 1863. Carboniferous to Permian.
  - Order 2. Aistopoda, Miall, 1874. Carboniferous to ? Permian.
  - Order 3.[1] Diplocaulia, nom. nov.
- Subclass III. Stegocephala, Cope, 1868. Carboniferous to Upper Triassic, ? Jurassic.
  - Order 1. Temnospondylia, Zittel, 1887. Carboniferous to Permian.
  - Order 2. Stereospondylia, Zittel, 1887. Carboniferous to Upper Triassic, ? Jurassic.

I am indebted to Dr. Leonhard Stejneger, of the United States National Museum, for the classification of the recent Amphibia.

VII.—On some Unrecorded Erratic Boulders in South Pembrokeshire.

By R. H. Chandler.

DURING the past year several igneous erratic boulders have been noticed on the cliffs of South Pembrokeshire by Mr. A. L. Leach and myself, in situations where no such erratics were previously known, so that a record of the larger ones seems advisable; five of them being dealt with in the following paper. At Mewsford Point, near St. Govan's Head, there is a well-rounded boulder measuring 4 ft. 1 in. × 2 ft. 6 in. and about 2 ft. 6 in. high, weighing approximately 32 cwt., and visible from some distance because its outline and dark colour differ markedly from the surrounding crags of Carboniferous Limestone. It appears to be the southernmost igneous erratic boulder in Pembrokeshire, and hence is of more than usual interest.

[1] The position of this new order is doubtful. It may belong to Subclass III. It is established for the genus *Diplocaulus*, Cope, from the Permian of Texas.

Mr. J. V. Elsden, B.Sc., F.G.S., kindly examined a microscopic section, and pronounced it to be "a typical enstatite-diabase, precisely like parts of the St. David's Head and Carn Llidi masses. I should say it certainly comes from there". There is a little drift containing igneous rocks in the immediate neighbourhood, capping the limestone plateau, and increasing to 6 feet at Pen-y-holt, 3 miles to the west; and a Boulder-clay 8 miles to the north-west.

By the roadside at Flimston Cottage (near Flimston Coastguard's Station) is a boulder roughly 3 ft. × 2 ft. × 2 ft. 3 in. high, weighing about 15 cwt., and having a very much weathered, rugose surface. Mr. H. H. Thomas, B.A., F.G.S., who kindly examined two slices of this boulder, regards it as "a brecciated spherulitic albite trachyte or rhyolite". He adds: "Rhyolites occur at a great number of places in Pembrokeshire, and all these rhyolites are not strikingly dissimilar from each other, but of all those that I have examined the Flimston Boulder seems to fit best with those of Roman's Castle, in the character of its spherulites and groundmass. I should think that it would be fairly safe to refer the boulder to that source."

Another large boulder occurs at Holloway Farm, Penally (used as a step to the wall of the farmyard), about 5 ft. × 1 ft. 6 in. × 1 ft. high, weighing approximately 9 cwt.; also a similar, but smaller, one on the foreshore at Lydstep Caverns, about 3 ft. × 1 ft. 6 in. × 1 ft. 6 in. and weighing about 7 cwt. Microscopic sections of each of these show ophitic structure, and are said by Mr. J. V. Elsden "to be in every respect identical with the rhombic pyroxene rocks of St. David's Head, and may be described as enstatite-gabbro or norite". The Holloway section, which is taken from the partially weathered crust, is not nearly so fresh as the one from the Lydstep shore; owing to the action of the sea on the latter the unaltered core is exposed, otherwise the two rocks are identical.

Another boulder, which occurs in the quarry on Lydstep Head, is a grit composed of angular quartz grains with some plagioclase felspar and mica, but is not distinctive enough to trace to its source; in size it measures roughly 3 × 3 × 2 feet, and would weigh about 13 cwt.

These three latter boulders (Lydstep Caverns, Lydstep Quarry, and Holloway Farm) are in an area almost devoid of drift on the cliff top, although igneous pebbles are abundant on the shore.

A glance at the map will show that the three boulders from St. David's Head have come over 30 miles from the north-west, and are separated from their parent rocks by St. Bride's Bay and Milford Haven, and by a considerable mass of fairly high ground (up to 250 feet O.D.).

The boulder from Roman's Castle is nearly 10 miles due south of its probable source, from which it is separated by Milford Haven and some high ground. Thus it is far from obvious by what route these erratics reached their present positions, although it might be by the Irish Sea Ice-sheet driving a stream from St. Davids eastwards over sea and land to deposit its boulders south-east of their sources.[1]

[1] F. W. Harmer, Quart. Journ. Geol. Soc., 1907, vol. lxiii, p. 474.

Fragments of Pembrokeshire rocks, glacially transported, have been traced as far east as Glamorganshire[1]; moreover, the shore drift contains in places abundant flint for which Ireland itself is not an impossible place of origin.

I am much indebted to Mr. J. V. Elsden and Mr. H. H. Thomas for kindly identifying the rock-sections of the boulders with their parent masses, and to Mr. A. L. Leach for chips of the Lydstep Boulders.

VIII.—Note on a Deposit of Allophane.

By R. H. Chandler.

In a denehole at Abbey Wood, near Plumstead, there is shown in the Chalk a fault of unknown extent (but probably having a throw of only a few inches), the plane of the fault roughly coinciding with one of the chamber walls. This wall has a strongly slickensided surface for some superficial yards, and extends to the roof of the chamber where the deposit of allophane is contained between the two fault faces. In some instances this mineral may be seen adhering to the fault face, and the roof of the denehole is composed of it for a length of about 7 feet by 2 feet wide; other patches are to be observed where the roof has been broken away, so that it seems evident the allophane extends horizontally some distance between the Chalk and the Thanet Sand; this latter is about 32 feet thick here. The deposit appears to be a roughly wedge-shaped mass, the greatest width being at the top of the Chalk, and from there diminishing downwards into tongues of the mineral extending between the two boundaries of the fault. Mr. J. L. Foucar, B.Sc., F.C.S., who kindly submitted a specimen to analysis for me, says: "I find the following to represent its composition:—

Moisture (loss at 100° C.)	23·19 per cent.
Loss on ignition, including some CO_2 not separately determined	20·77 ,,
SiO_2	28·80 ,,
Al_2O_3	23·52 ,,
CaO	2·45 ,,
Loss and undetermined	1·27 ,,
Fe	traces
	100·00 ,,

He adds: "The mineral is undoubtedly a variety of allophane, although its composition does not correspond with the formula $Al_2Si O_5 5H_2O$. It has recently been shown[2] that the minerals of the allophane group are probably merely amorphous mixtures of hydrated oxides of silicon and aluminium, plus certain impurities. The chief impurity in this present case is calcium carbonate, and perhaps calcium silicate, the source of whose origin is obvious."

In colour the mineral is cream to buff, veined with a darker shade of brown having a waxy lustre, is rather friable, occasionally

[1] F. T. Howard & E. W. Small, Trans. Cardiff Nat. Soc., 1899, vol. xxxii; also *Geology of the South Wales Coalfield*, pt. viii, Mem. Geol. Surv., 1907.

[2] H. Stremme, Centr. Min., 1908, pp. 622–32, 661–9.

contains little pellets of ferruginous material, and the outside layer is in places crystalline.

The extent of the deposit is unknown, but there are at least 4 or 5 bushels in sight, and every evidence that the seam is much more extensive at the junction of the Thanet Sand with the Chalk, which is about 2 feet above the roof of the denehole.

Professor John Morris[1] in 1857 described the occurrence of allophane at Charlton (the first English record), and gave an account of the condition and position of deposit which seems to be essentially the same as above described. He also gives the analyses of several allied minerals, all of which differ from the analysis given here; however, the constitution of Professor Morris' allophane approximates remarkably to Mr. Foucar's analysis, the only difference being 10 per cent. more silica and 10 per cent. less alumina, the water and impurity being exactly the same. A comparison of the Charlton and Abbey Wood allophanes and a specimen from Beauvais are given below.

	Silica.	Alumina.	Water.		Analysis by
Charlton Allophane (Prof. Morris) . . .	18·89	33·52	42·73	Carb. lime 4·38	Dick.
Abbey Wood ,, (R. H. C.)	28·80	23·52	42·04	,, 4·37	J. L. Foucar
Beauvais ,, (Prof. Morris) . . .	21·90	29·20	44·20	Clay 4·7	Berthier

The above is, so far as I can ascertain, the largest deposit yet recorded, other notices speaking of 'some' allophane being reported, and although no definite quantities are stated, the implication is that the amount was small.

Since writing the above Mr. Foucar has been good enough to analyze another specimen, with the same results as given before.

REVIEWS.

I.—The Geological Society of Glasgow and its Jubilee.

History of the Geological Society of Glasgow, 1858–1908, with Biographical Notices of Prominent Members. Edited by Peter Macnair, F.R.S.E., F.G.S., and Frederick Mort, M.A., F.G.S., etc. 8vo; pp. vi, 303, with 24 portraits and 2 other illustrations. Glasgow: published by the Society, 207, Bath Street, 1908. Price 6*s*.

THIS volume was prepared to commemorate the Jubilee meeting of the Society, which was held at Glasgow on January 28. In the opening chapter a brief sketch is given of the geological features of the Clyde Valley, to which the Society has naturally given special attention; and biographical notices are inserted of some of the geological workers who had studied the rocks and fossils in earlier days. Among these were the Rev. David Ure, author of *The History of Rutherglen and East Kilbride* (1793), a work of great merit in

[1] Quart. Journ. Geol. Soc., vol. xiii, pp. 13–17.

which the fossils of the district were described, and most of them so well illustrated that the species can be easily identified; John Craig, a practical geologist and mineral surveyor, who conducted classes and gave lectures on geology; and Dr. John Scouler, for some years Professor of Mineralogy to the Royal Society of Dublin, and afterwards President of the Glasgow Geological Society from 1859 to 1862, whose name is associated with a species of *Eurypterus*.

The chapter on the Origin and Early History of the Society is reprinted from a paper by Mr. T. M. Barr (1883). It appears that as early as 1840 there was in existence a Glasgow Geological Society, of which no particulars can be obtained, further than the mention of it on a handbill announcing two lectures by Mr. John Craig on the geology and mineral resources of the west of Scotland. In 1850 a society under the same name was established by members of Mr. Craig's class, when he was chosen as president, and James Smith, of Jordan Hill, consented to be Honorary President. This society, however, ceased to exist early in the following year.

The present Society was founded at a meeting held in May, 1858; it was started by William Kirkland, Hugh Reid, Thomas M. Barr, and George M. Barr, students keenly interested in geology, and at the first meeting they were supported by Edward A. Wünsch, who was then elected Vice-President and was an active supporter until 1881, when he went to reside in Cornwall. Among those who joined at an early date were James Thomson and the Rev. H. W. Crosskey.

Various excursions were made during 1858, one to Arran, under the guidance of Dr. James Bryce, another to the Campsie District, under John Young, afterwards Assistant Keeper of the Hunterian Museum at Glasgow.

James P. Fraser, F.R.S.E., was chosen as the first President in October; but it was not until 1860 that the rules and a complete list of members (178 in number) were printed, and in the same year a lecture on "The Geology of the Campsie District", delivered by John Young in 1858, formed the first paper issued by the Society in the form of 'Transactions'.

In the course of 1859 lectures by David Page, James Bryce, Dr. Scouler, and others served to foster an interest in geology.

The Society soon became firmly established, and during its first ten years it was joined by James Smith of Jordan Hill, Dugald Bell, David Robertson, D. C. Glen, Robert Craig, James Croll, James Armstrong, Professor John Young, and Sir Archibald Geikie (as an Honorary Member). Dr. Robert Slimon, whose name is perpetuated in the genus *Slimonia*, was elected a corresponding member. In later years Sir William Thomson was chosen President and served for twenty-one years (1872–93), towards the end of which period he became President of the Royal Society, and was created Baron Kelvin.

An important section of the volume is the review of the fifty years' work comprised in the Transactions of the Society. It is divided into five chapters. That on Physical and Dynamical Geology is by Professor J. W. Gregory, who points out the large field of study open to Glasgow Geologists, their province extending from the Southern Uplands of Girvan and Moffat to the North-West Highlands, and to

the Inner and Outer Hebrides. The work of Lord Kelvin on Geological Time, of Sir A. Geikie on Modern Denudation, and many other subjects are noticed, including Mr. J. G. Goodchild's solution theory of igneous intrusion. Mineralogy and Petrology are dealt with by Mr. Joseph Sommerville, and Stratigraphical Geology by Mr. Macnair, who treats with appropriate enthusiasm Professor Lapworth's researches on the Southern Uplands, and notices many papers on the Carboniferous rocks and other formations. The article on Palæontology is by Mr. James Neilson, in which further particulars are given of the older rocks and their organic remains. The labours of James Armstrong, regarded as the leading palæontologist of the Society, are specially mentioned, and a full account is given of researches relating to the Carboniferous fossils.

Discussing the zonal classification of Dr. Vaughan, Mr. Neilson points out how the range of certain species in Scotland differs from that in the British area, and observes that he has been led to consider many of the mutations of species as due to environment.

Mr. John Smith, who is stated to be the father of the Society, gives a summary of the work done on Glacial Geology. One of the earliest papers, of which brief mention is made, is that now classic essay "On the phenomena of the Glacial Drift of Scotland", by Sir A. Geikie (1863), referred to at the jubilee meeting by Professor J. W. Gregory as a paper which "at once lifted British glacial geology on to a new plane". Mr. Smith, who has dealt in detail with the Glacial Deposits of Ayrshire, expresses his belief in the marine origin of the boulder-clays.

Three chapters are occupied with Biographical Notices of Members and of some other geologists who have been associated in the work of the Society, many of the short memoirs being accompanied by portraits.

The concluding chapter deals with the present position of the Society, and it is noted that forty years ago the number of members was 231, now it is 228. It is remarked that "In most sciences the day of the amateur has departed. Palæontologists tell us that the great mammals of Tertiary times disappeared through over-specialisation. In many branches of geology the amateur, at any rate as a large contributor of original work, is being hurried to extinction by the same cause". There is, however, abundant work for geologists who have had no "highly technical training", if only they are not dismayed by modern palæontological nomenclature. The volume will be appreciated by those interested in the history and progress of geology, and it will be a valuable work of reference to those engaged in a study of the rocks and fossils of Western Scotland.

It was appropriate that Sir Archibald Geikie, who was elected an Honorary Member of the Glasgow Geological Society in 1863, and served as President from 1893 to 1896, should be invited to give an address at the jubilee meeting. The ceremony, which was held at the University buildings, took the form of a conversazione, the guests being received by the Principal, Sir Donald MacAlister, K.C.B., and Lady MacAlister, together with Sir A. Geikie, Professor J. W. Gregory (President of the Glasgow Geological Society), and Dr. B. N. Peach.

In his address Sir A. Geikie gave a picturesque outline of the geological features of the surrounding district, and referred to the work of the pioneers—Faujas de Saint-Fond, the first geologist to set foot on Staffa; James Hutton (the father of modern physical geology), whose observations in Arran demonstrated the intrusive nature of the granite and the whinstone dykes; and John Macculloch, famed for his researches on the Western Isles. Ami Boué, again, was mentioned as the author of the *Essai Géologique sur l'Écosse*, published in 1820, and A. C. Ramsay, who wrote an early account of the geology of Arran.

Among those who had conspired to raise in Glasgow an interest in geology, Sir A. Geikie was disposed to give the foremost place to James Smith, of Jordan Hill, who first called attention to the general lowering of the temperature in the Pleistocene period by his observations on the boreal mollusca of the Clyde Beds. He thus paved the way for subsequent researches on the records of the Glacial period, to which the members of the Glasgow Geological Society have so largely contributed. Indeed, on this subject they have rendered their most important services to geological science.

II.—Gold: its geological occurrence and geographical distribution. By J. Malcolm Maclaren, D.Sc., F.G.S., F.R.G.S., M.I.M.M., late Mining Specialist, Government of India, formerly Assistant Government Geologist, Queensland, etc. pp. xxiii + 687, with one coloured plate and 278 illustrations. London: *The Mining Journal*, 1908. Price 25*s.* net.

FROM the very earliest time gold has, on account of its magnificent colour and its durability, been highly prized for ornamental purposes, and as the recognized medium for the exchange of commodities throughout the civilized world it is at the present day in ever increasing demand. The literature concerning it is immense. The quest for it has carried men to the heat of the tropics and the chill of arctic regions. Prospectors are constantly searching for new fields, and the observations of individuals are supplemented by the careful studies of skilled geologists. Consequently the data relating to the occurrence of the precious metal steadily grows. Apart from the extreme importance of the matter from the economic point of view, the distribution of such well-defined minerals as gold and its compounds serves to throw light upon the origin of ore-deposits.

In the preface to the book Dr. Maclaren tenders something in the nature of an apology for adding to the literature of ore-deposits; but surely none would be demanded by the most captious of critics. It is, indeed, from the pen of one who has had occasion to visit many of the principal mining regions and who has had the knowledge and the energy to enable him to take advantage of the opportunities afforded him that a work such as this is welcome. The slight inequality that may be detected here and there in the treatment is almost inevitable in a book, the writing of which has extended over a number of years, and can well be excused.

The book is divided into two main parts. The first of them deals

with the general relations of auriferous deposits. After a brief introductory chapter upon the processes which have led to ore-deposits, the author proceeds to describe carefully and fully the crystalline characters of gold and its native alloys and compounds. The text is accompanied by numerous excellent drawings of typical crystals, and good illustrations of various well-crystallized nuggets are given on plates, the frontispiece being a coloured picture, natural size, of the fine nugget—the "Latrobe"—which is treasured in the British Museum collection. The statement on p. 29 regarding the telluride of gold, calaverite, that "such crystallized specimens as have been found have been too imperfect to admit of the determination of the crystallographic system", was probably penned prior to the discovery some ten years ago of numerous brilliant many-faced crystals at Cripple Creek. The precise system is, indeed, still in doubt on account of the extraordinary complexity of the crystallization. The number of forms that have been observed on the rare mineral krennerite is considerably larger than that given on p. 33. The next chapter is concerned with the classification of auriferous deposits. Dr. Maclaren dismisses all systems which are based upon considerations of the form of the deposits and the nature of the association as useless from either a scientific or an economic point of view. Gold has often been found in the last place that might have been expected from the theoretical considerations put forward by various writers. Upon this still debatable point the author is not dogmatic, but thinks that the gold-bearing regions may conveniently, if empirically, be grouped according to a combination of geographical and geological data as follows: primary, (*a*) connected with the extrusion of intermediate or basic igneous rocks (andesites or diabases), (*b*) connected with the extrusion of acid rocks of granodioritic type; secondary, (*a*) deposits produced or modified by chemical agencies, (*b*) deposits produced by mechanical agencies. The primary group is defined to include gold which has had apparently "no prior state of combination and no former locus in space"; the metal in the secondary group is "obviously or presumably derived from sulphide or telluride ores, or from gold-quartz". Such a classification clearly cannot be considered very hard and fast, but pending further research it serves the purpose. Typical examples of the various sub-groups in different parts of the world are briefly described. Many important questions are discussed in this chapter, such as the formation of nuggets, about which there has been so much controversy, and the deposition and concentration of gold.

The second part, which occupies nearly three-quarters of the book, comprises full descriptions with great wealth of detail of all the known occurrences, arranged geographically — Europe, Asia, Australasia, Africa, America—and furnishing most fascinating reading. So far as possible, the author gives for each district the history of the mines, the geological features, the methods of working, and statistics of the output. The text is accompanied by many admirable illustrations, both plans and reproductions of photographs of various districts. Adequate discussion of this part is beyond the limits of a review: we can but commend the reading of it.

At the end of the book will be found copious and carefully compiled indices, of which the geographical index especially will be of great use for the determination of the locality of some little known mine.

The printing and appearance of the book are beyond reproach. We may safely predict that Dr. Maclaren's treatise is destined to fill a high position in the literature of gold.

III.—Brief Notices.

Vertebrate Remains in Asphalt.—Mr. J. C. Merriam, Associate Professor of Palæontology and Historical Geology in the University of California, has contributed an interesting article on the vertebrate remains obtained in an asphalt deposit a few miles west of the city of Los Angeles, in California (*Sunset*, San Francisco, October, 1908). Quite recently the occurrence of many extinct animals in this deposit has been brought to notice. Among the remains are those of gigantic wolves, the sabre-toothed tiger, camel, elephant, and large sloths. Many birds and other remains were also obtained. Of the *Machærodus* Professor Merriam remarks: "At one locality eighteen complete skulls, and at least one complete skeleton, were found within an area of less than two square yards." In other places certain layers of the asphalt proved to be nearly barren of fossil remains. The deposits appear to have been formed "from the slow accumulation of bituminous material around tar springs". In time a large pool of the material would have collected, and become more or less hardened, but in warm weather the surface would be rendered soft, and thus act "as a trap for unwary animals", which would be entombed in successive accumulations of the asphalt.

Burning Cliffs at Lyme Regis.—Since the note by Mr. Cameron was received, our attention has been called to a paper on "The Burning Cliff and the Landslip of Lyme Regis", by Mr. A. J. Jukes-Browne, published in the Proceedings of the Dorset Natural History and Antiquarian Field Club, 1908, vol. xxix, p. 153. He gives a view of the burning mound at Lyme, and has reproduced a view of the burning cliff at Holworth, Dorset, 1827.

Tsetse Fly in the Miocene.—Mr. T. D. A. Cockerell reports the discovery of another fossil tsetse fly in the Miocene shales of Florissant, Colorado. He proposes to give the name *Glossina osborni* to this new species. (*Nature*, April 1, 1909.)

The Devonian Fishes of Iowa.—These form the subject of a memoir by Mr. Charles R. Eastman, published by the Iowa Geological Survey, 1908, vol. xviii. The author gives an interesting introduction on the "Aim and general outlook of palæontological inquiry, and relations of palæichthyology to biology". He observes that detached teeth and other fragmentary fish-remains occur somewhat sparsely in the Middle Devonian of Iowa, while in the Upper Devonian they occur in remarkable abundance and locally constitute veritable fish-beds. The local strata consist of limestones and shales. The title of the memoir should have been the Devonian fishes of North

America, with special reference to the fishes of Iowa, as the author deals generally with the subject and gives a full list of the Devonian fishes of North America. Some of the species are grouped, according to Cope, in the class Agnatha, a lower grade than fishes proper; and these include the *Asterolepis*, *Bothriolepis*, and *Cephalaspis*, but none of them are recorded from Iowa. The local genera include *Conchodus*, *Dinichthys*, *Dipterus*, *Heteracanthus*, *Onychodus*, *Ptychodus*, *Rhynchodus*, and *Synthetodus*. The work is accompanied by thirteen plates of fossils and three palæogeographic maps.

Scottish 'Eenie' Coal.—Under this title Mr. C. T. Clough and Mr. James Kirkpatrick describe a variety of coal which on certain surfaces shows circular structures bearing a resemblance to 'een' (eyes). These structures, though common, are seldom so well developed as to attract attention. The authors, however, state that "A few months ago some unusually good specimens were found in Gateside colliery, Cambuslang, and these certainly are merely superficial structures, closely allied probably to conchoidal fractures, which are found on certain joint-planes. They must, however, have been formed by some natural action, perhaps by pressure acting specially on certain points, along planes which were probably also produced by pressure at some far distant period; and, since that period, thin films of spar of various kinds—calcite, a ferriferous carbonate, quartz, iron pyrites, and more rarely galena—have been deposited along many of the joint-planes, and have often taken the form of the 'een' with which they are in contact. Such spathic 'een' are, however, by no means always present". (Paper read before the Mining Institute of Scotland, Trans. Inst. Mining Engineers, 1909, xxxvii.)

The Royal School of Mines.—Mr. F. W. Rudler, I.S.O., F.G.S., presided at the thirty-sixth annual dinner of the old students of the School, which took place at the Hotel Cecil on April 30. In the course of his reply to the toast of "The Royal School of Mines", the Chairman remarked on the official ups and downs which the School has undergone, observing that "at last it has settled down under the shelter of the Imperial College of Science and Technology, but with its individuality, its name, and its associateship unimpaired". These words are reported in the *Mining Journal* for April 3, but in an article in the same journal on "Mining Education in the British Empire", we find remarks on "the threatened extinction of the diploma (A.R.S.M.). This, if it eventuates, will certainly be nothing less than a calamity. An A.R.S.M. has a market value . . . and it is a distinct injustice to demand that students, who go through a course at what is to all intents and purposes the Royal School of Mines, should in future go abroad with the mystic and unknown symbol A.I.C.S.T. after their names". We trust that this is a false alarm.

Red Granite of the Transvaal.—In his Anniversary Address to the Geological Society of South Africa, 1909 (Proc. Geol. Soc. S. Africa for 1909, pp. xxi–xxx), Mr. H. Kynaston chose as his subject "The Red Granite of the Transvaal Bushveld and its Relation

to Ore Deposits". The area occupied by this granite, with its peripheral belt of basic rocks and sundry smaller intrusions of syenite—the whole usually termed the igneous complex of the Bushveld—has been estimated at about 15,000 square miles, without including some concealed portions of the granite. A great variety of rocks is met with in this complex, from peridotite to granophyre; and if the magnetite bands in the norite may be regarded as a further ultra-basic modification, there would be an extreme example of magmatic differentiation, with magnetite rock at one end of the series and quartz rock at the other. After describing the structure of the rock-masses and their general mode of intrusion, Mr. Kynaston referred to the valuable deposits of tin-ore which had been discovered in the Red Granite and in some rocks into which it has been intruded. Ores of copper, silver, lead, zinc, cobalt, nickel, and iron, and occasional gold-bearing quartz are also known; and their modes of occurrence and origin are discussed.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—*February* 24, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Palæolithic Implements, etc., from Hackpen Hill, Winterbourne Bassett, and Knowle Farm Pit (Wiltshire)." By the Rev. Henry George Ommanney Kendall, M.A. (Communicated by W. Whitaker, B.A., F.R.S., F.G.S.)

Implements are described from the localities mentioned in the title, which lie at heights of 885, 576, and 450 feet above O.D. respectively. Hackpen Hill forms a ridge of Chalk running north and south, capped by patches of Tertiary Clay. Trimmed stones of eolithic nature were obtained from fields ploughed in Drift gravels, together with abraded Upper Greensand chert, quartzite pebbles, and small flints. The greater number of the flaked stones were found within and near shallow pits excavated in yellow Drift clay, apparently newer than the Red Clay with Flints, exposed at the edges of the larger hollows. The implements are unabraded, abraded, and striated; some stained brown, some green, others unstained; evidently some are *in situ*, others were brought with the Drift. Implements taken from the clay are described, and a distinction is made between the palæoliths and neoliths obtained from the same surface. The similarity in the mineral condition of the former to palæoliths from Knowle Farm Pit is pointed out, and both are referred to the Chelléen period.

It is noteworthy that, while implements and flakes are numerous on the top of Hackpen Hill as compared with good, trimmed pieces,

yet at this 570 foot level on the Winterbourne Bassett plain implements and flakes are very scarce, while trimmed pieces are very numerous, although the level of the Winterbourne Stones is 300 feet lower. Many of the latter, however, have been evidently re-chipped, and are therefore of later date. The author concludes that implements of at least three Palæolithic periods are found at Knowle, and these three periods may be compared with the Chelléna, Lower Acheulien, and Upper Acheulien of Professor Commont et St. Acheul. Still older implements (possibly earlier Chelléen) seem also to occur.

2. "On the Karroo System in Northern Rhodesia, and its relation to the General Geology." By Arthur John Charles Molyneux, F.G.S.

In 1903 (Quart. Journ. Geol. Soc., vol. lix) the author described the occurrence of deposits, that have since been recognized as of Karroo age, in Southern Rhodesia. The present communication traces their extension across the Zambesi, where their boundary follows the foot of the remarkable line of escarpments that divide the plateau, nearly 4,000 feet in altitude, from the low-lying (1,500 feet) regions of the Zambesi Valley. Karroo deposits also form the floor of the peculiar trench-like valleys of the Luangwa, Lukasashi, and Lusenfwa (or Luano), the walls of which are similarly steep, and of metamorphic rock gneiss, schist, and granite.

The Luano Valley is described. Its northern precipice is known as the Machinga (native meaning 'a fence'), and the Lusenfwa and Molongushi Rivers are followed in their mature courses across the flat plateau plains. They reach the Luano by waterfalls into deeply incised gorges, cutting back 15 and 8 miles respectively into the plateau. Rivers that join the Luano from the south, on the contrary, descend into open valleys of Karroo floors, that are divided one from the other by tongues from the southern highlands, and suggest 'rolled-out' folds.

Between the Kafue junction and Feira the Zambesi River also occupies a trough valley, lined by steep escarpments; that on the south side rises 2,000 feet in less than a mile, being formed of a flexure of altered sediments. The Danda flats show Karroo beds.

The Lufua River runs parallel with the strike of the gneiss of the locality, and crosses two synclinal basins of clastic deposits, separated by Archæan ridges. The Losito has also a deep strike channel.

The Karroo deposits are grouped into basal conglomerates, Coal-measures, Upper Matobola Beds, and Escarpment Series. No effusive basalts were seen, but there is an area of Forest Sandstones near the Losito-Zambesi confluence. In the Luano Valley the conglomerates are made up of resisting quartz, quartzite boulders and pebbles, all having dimpled or concave depressions on one or more sides; they possess no orientation, are unsorted, and exhibit a varying matrix. Though they form the base of the Karroo System there is no certain evidence of glaciation, but the beds seem to have originated as scree deposits on an uneven floor. The grinding of

the pebbles into one another is accounted for by the soft nature of the schists and limestones, which would have been removed in the internal movement before consolidation.

In the Lukasashi and the Luano there is a general dip of the strata north-westwards, that is, towards the escarpment, and evidence of minor anticlinal and synclinal folds along east-north-east axes. By a combination of these the Karroo deposits become lowered from plateau level on the south, towards the north-west culminating in a great downthrow fault along the foot of the Machinga.

Nowhere on the plateau in the immediate vicinity of the valley walls have Karroo beds been found, and if they did once extend there it is remarkable that they should have disappeared. But it is certain that the valleys were at one time filled almost to plateau level, as the rivers pass through Archæan inliers by deep clefts, and must thus have laid out their courses before such hard masses rose from the Karroo beds by erosion of the latter. Also the comparatively late times in which the Machinga escarpment was laid bare, and the rejuvenation of the Lusenfwa River, etc., suggest a complete filling of the valleys.

It is thus possible that the Karroo beds extended over a part of the plateau, and were included in the folding and faulting movements already mentioned. Subsequently, by some continuous agency the whole surface was planed off to a plateau of remarkable monotony; and on a further radical change of conditions taking place, erosion of the softer Karroo strata set in by which the present valleys are again reaching a plane of denudation.

The facility with which atmospheric waters and acids attack the sediments is notable, and decomposition extends to 100 feet in depth over the flat regions of the plains.

The author suggests that the trough valleys of clastic rocks merely follow the axis of pre-Karroo and post-Karroo movements, trending in three directions. The Luano and part of the Zambesi course agree with that of the folds and cleavage of the complex, certain ranges of hills, and the Machinga Fault (east-north-east); a second (south-easterly) trend is that of the Kafue, Losito, Inyanga range, and Lufua, and the folds and cleavage of the complex in these regions; while the third follows the dominant direction of the great tectonic movements of South Africa (north-east). Mr. L. A. Wallace has noted that the Luangwa and mid-Zambesi are on this strike, and Mr. G. W. Lamplugh has suggested a northerly extension of his Deka Fault. A distance of 800 miles thus displays movements that commenced in pre-Karroo periods, and have repeated themselves since the Karroo time.

Fossils from the areas described support the previous allocation of the deposits to the Permo-Carboniferous and to the Karroo System of South Africa. Notable specimens are members of the *Glossopteris* flora, including pith-casts of *Schizoneura*, carapaces of *Estheria*, ostracods, and fragments of bone, fish scales, and teeth.

Palæolithic stone implements (axe-heads) were found at separate localities on the surface, about the latitude of 14° 50′ S.

3. "Plant-containing Nodules from Japan, considered structurally in their relation to the 'Coal-Balls' and 'Roof-Nodules' of the European Carboniferous." By Marie C. Stopes, D.Sc., Ph.D. (Communicated by Professor E. J. Garwood, M.A., Sec.G.S.)

These nodules are of interest because of the plant and animal fossils that they contain. The plant-petrifactions are of a type unknown from the Mesozoic, and will be described separately. The nodules are of Cretaceous age. They enclose numerous marine shells and various plant-remains, well petrified. Unlike the 'coal-balls' and 'roof-nodules', they are not contained in coal-seams or in the roof thereof, but occur in a thick series of shales below the coals, which appear to be of Tertiary age. The microscopic aspect of the matrix shows that it is highly granular, unlike the matrix of coal-balls and roof-nodules. Chemically they consist of about 60 per cent. of carbonates, both lime and magnesia being present, with 30 per cent. of silicates; the large proportion of silicates is an important point of difference from the Carboniferous nodules. In having numerous plant-fragments in a single nodule and in the type of petrifaction the nodules are like coal-balls; in having marine shells included in the matrix they are more like roof-nodules. They probably represent fragments of tangled débris, which drifted out to sea but a short distance and then were speedily petrified. The authoress acknowledges help from the Government Grant Committee of the Royal Society in carrying out the research, and also from the Japanese Government, the Imperial University, and the local Government of Hokkaido, together with the Tunko Kaisha of Hokkaido.

2.—*March* 10, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Some Notes on the Neighbourhood of the Victoria Falls, (Rhodesia)." By Thomas Codrington, M. Inst. C. E., F.G.S.

The author gives an account of the way in which the basalt lies in the valley of the Zambesi below and above the Victoria Falls, and points out how that has determined the features of the river. The basalt through which the Batoka Gorge has been cut appears in the course of the Zambesi for 2 miles above the Victoria Falls, causing rapids over rocky bars between many islands. It then disappears, and the river above flows quietly between alluvial flats for 5 miles, the basalt being traceable here and there below the water until above Candahar Island it again rises and constitutes the bed of the river from bank to bank, causing rapids that extend for many miles up the river. Attention is called to a wide tributary valley which joins the main Zambesi Valley on the east at the Falls; and to the Maramba River flowing down it, and its fluviatile deposits. The discovery of stone implements and artificially worked stones in the gravel and the bed of the Maramba is noted.

The difference observable in the artificially worked stones from defined areas on both sides of the Zambesi is shown by a comparison of numerous specimens collected by the author. The very large majority of flakes and flaked stones having no trace of design over those that can be considered as implements, however rough, suggests that the manufacture of stone tools on a large scale was here carried on for use in the sand-covered country on both sides of the Zambesi, where there is no stone; and the difference in the proportion of sharp unworn specimens to those apparently water-worn seems to show that while many were made on the ground, the flakes and refuse of the making of many more were brought down from the tributary valley on the east.

The author considers that there is no evidence as to the age of the implements found near the Zambesi; none have been discovered in gravel that belongs to that river, and the presumption appears strong that they were made from quartzite found on the surface since the Batoka Gorge was eroded.

2. "A Contribution to the Petrography of the New Red Sandstone in the West of England." By Herbert Henry Thomas, M.A., B.Sc., F.G.S.

The paper is supplementary to that which dealt with the mineralogical composition of the Pebble-bed, and was published in vol. lviii of the Quarterly Journal (1902), p. 620. The results obtained are based on the microscopic investigation of a large number of samples taken from various New Red horizons and localities in Devon and Somerset.

The author gives a list of minerals identified, and tables showing their distribution. In the description of certain mineral species, it is suggested that anatase occurs both as detrital crystals and as crystalline groups formed in the rocks since their deposition. The forms presented by grains of staurolite as well as certain crystals of tourmaline with an unusual habit are described.

It is recognized that the various divisions of the New Red Sandstone, namely, the Lower Breccias and Sandstones, the Lower Marls, the Pebble-bed, and the Upper Marls and Sandstones, although linked together by a general similarity of mineralogical composition, present physical and mineralogical differences indicative of variations in the source of supply and conditions of deposition.

The rounding of the grains is most complete (millet-seed) in the sandstones of the Lower Breccias and Sandstones, a feature continued, but in a less striking manner, into the overlying division.

With regard to the vertical and horizontal distribution of minerals, it is found that staurolite is abundant in the Lower Breccias and Sandstones of the extreme south of Devon, but less plentiful northwards; that garnet is present in all the New Red rocks of North Devon and Somerset, but in South and Central Devon only occurs in the Lower Marls and in the Upper Marls and Sandstones.

3.—*March* 24, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communication was read:—

"Glacial Erosion in North Wales." By Professor William Morris Davis, For. Corr. G.S.

An excursion around Snowdon in September, 1907, followed by a further visit in 1908, led the author to the conclusion that a large-featured, round-shouldered, full-bodied mountain of pre-Glacial time, had been converted by erosion during the Glacial Period—and chiefly by glacial erosion—into the sharp-featured, hollow-chested, narrow-spurred mountain of to-day. The peculiar indifference of topographic form to the trend of formation boundaries and the insequent stream arrangement, are what might be expected as the result of prolonged erosion upon a mass of complicated and resistant structure. The author discusses Ramsay's theory of a plain of marine denudation, and is of opinion that the upland seems to deserve classification rather with peneplains; he suggests for it a Tertiary date, which would not be inconsistent with the erosion of open valleys in the uplifted peneplain after its elevation, and argues that Snowdon and its high neighbours had a relief of some 2,000 feet above the plain. As the result of a comparison with the non-glaciated regions of Devon, it is considered that the dissection of North Wales must have been somewhat less developed in pre-Glacial times than in Devon to-day. On this assumption it is possible to make a tentative restoration of the pre-Glacial form of Snowdon: subdued mountains, with dome-like summits and rounded spurs, drained by prevailing graded streams of accordant levels at their junctions. In fact, the characters were those of 'moels' such as Moel Tryfaen or like the well-worn Appalachian Mountains of North Carolina or the Cévennes.

The chief abnormal features of Snowdon are the following:—Alongside the graded summit and slopes of a 'moel' stand the head-cliffs of a rock-walled cwm, in the floor of which talus is now accumulating. The cwm-floors are generally stepped, sometimes more than once, and the streams cascade down into the valleys. The cross-profile of the valleys is often a fine catenary curve, down the sides of which streams fall from hanging valleys. The slope of the main valleys occasionally decreases even to the point of reversal, as where lakes occur; and in the immediate neighbourhood of smoothly graded, waste-covered slopes knobby or craggy ledges and bars of rock often appear. After pointing out that such features are generally associated with glaciation, the author proceeds to discuss two out of four possible hypotheses put forward: "that glaciers are essentially protective agencies," or that they "are active destructive agencies". The consequences deduced from the hypotheses are confronted with the actual facts, and it is found that these, and especially those relating to rock-steps, cannot be explained on the protection-theory, while the theory of a destructive agency seems to explain most of the facts.

These facts are dealt with under the following heads:—Valley-head curves; valley-floors, lakes; valley-floors, rock steps; valley-

sides; hanging lateral valleys; and glacial overflows. With regard to the first, it is shown that there is no systematic relationship between the height of the cwm-cliffs and the distance of the front rock-step; the serration of 'cribs' or arêtes cannot be explained by pre-Glacial or post-Glacial weathering according to the protection theory. It is suggested that it might be possible on the erosion theory to work out and classify cwms according to their age and growth, and as a contribution to this enquiry the cwms of Mynydd Mawr are dealt with. The valley-lakes are likely to be only a small part of the glacial erosion. No consistent explanation of the valley-steps can be found under the theory of ice-protection, whereas they are explicable on the assumption of glacial erosion. They may have originated in resistant beds, and have then retreated up the valleys. The catenary curve of the cross-section of such valleys as those containing Llyn Gwynant and Llyn Cwellin might be expected to result from long-continued ice-erosion; and the occurrence of great cliffs on the sides of these valleys is not inconsistent with such an origin. Several good examples of hanging valleys occur, and they seem to show that the deepening of the main valleys by glacial erosion may be from 200 to 400 feet, and in some cases as much as 500 or 600 feet. The lateral erosion may easily amount to 1,000 or 1,500 feet. The most striking case of a glacial overflow is that at the head of the Nantlle valley, which appears to have carried much of the West Snowdon ice. The head of the pass would seem to have been farther westward and higher in pre-Glacial times.

II.—Palæontographical Society.

THE sixty-second annual meeting of this Society was held in the rooms of the Geological Society, Burlington House, on Friday, March 19, Dr. Henry Woodward, F.R.S., President, in the chair. The Report of the Council referred to the completion of the Monograph of Cretaceous Asteroidea, and to the satisfactory progress of the Monographs of Chalk Fishes, Cretaceous Lamellibranchia, Cambrian Trilobites, and British Graptolites. Numerous proposals for new monographs had been received, but the Council were desirous, so far as possible, to complete those in progress before entering upon further undertakings. The Society had sustained several serious losses by death during the year. The late Mr. W. H. Hudleston was a Vice-President and a distinguished contributor. Professor Albert Gaudry had been a member for many years. Sir Thomas Wardle was also an old member, and had served for some time on the Council. An appeal was made for new subscribers to replace these and other members who had been lost. Sir Archibald Geikie, K.C.B., Pres. R.S., was elected a Vice-President in place of the late Mr. Hudleston. Professor E. J. Garwood, Mr. C. Fox-Strangways, and Mr. F. R. Cowper Reed were elected new members of Council. The officers were re-elected—Dr. Henry Woodward as President, Dr. G. J. Hinde as Treasurer, and Dr. A. Smith Woodward as Secretary.

III.—Mineralogical Society.

March 23, 1909.—Principal H. A. Miers, F.R.S., President, in the Chair.

On a Stage Goniometer for use with the Dick pattern of microscope; by Professor H. L. Bowman. The form of goniometer, intended to be screwed to the stage of a microscope with rotating nicols, which was designed by Principal Miers, has been slightly modified by the author with a view to securing increased rigidity and ease of control. The instrument is adapted for supporting and manipulating a small crystal during the examination of etching-figures or other features requiring high magnification, as well as for the determination of its optic axial angle in air or oil, and the extinction angles and other optical characters of the various faces. It is provided with screw motions for adjusting and centreing the crystal, and for regulating the height of the axis above the stage.—On the Electrostatic Separation of Minerals; by Mr. T. Cook. Conductivity is a much more important factor than specific gravity in determining the behaviour of mineral fragments under the influence of an electrostatic charge. The greater susceptibility of good conductors as compared with bad conductors can be made still more pronounced by providing for the escape of the repelled opposite charge, which takes place rapidly in good conductors and slowly in bad conductors. It was shown that, in consequence of this fact, grains of such good conductors as ilmenite, pyrites, galena, or wolfram can be easily separated by means of a rubbed piece of sealing-wax from admixed grains of bad conductors such as calcite, quartz, fluor, or monazite. Minerals having a metallic lustre are good conductors, whereas those which are colourless and highly transparent are bad conductors. It is suggested that there is probably a much closer connection between the conductivity of a mineral and its general optical properties than has been hitherto suspected.—On the identity of Guarinite and Hiortdahlite; by Dr. F. Zambonini, with chemical analysis by Dr. G. T. Prior. The rare mineral guarinite, which occurs sparingly in small yellow crystals in the sanidinite bombs of Monte Somma, has been hitherto regarded as ortho-rhombic, and as essentially a complex silicate of lime, alumina, and soda. A new investigation made by the author on crystals showing terminal faces shows that the mineral is really triclinic, and identical, both crystallographically and optically, with hiortdahlite. Crystals of guarinite show polysynthetic twin lamellæ with oblique extinctions like those exhibited by crystals of hiortdahlite. The chemical analysis showed that the mineral is essentially a fluo-silicate and zirconate of lime and soda, practically identical in composition with hiortdahlite, although the percentage of fluorine was lower than that given in Cleve's analysis of the latter mineral. The numbers obtained in the analysis correspond closely to a formula $3\,Ca\,Si\,O_3 . Ca\,(OH, F)\,Na . Zr\,O_3$.—Note to a paper "On the Comparison of Refractive Indices of Minerals in Thin Sections"; by Dr. J. W. Evans. Parallel nicols are placed so as to bisect the angle between the directions of vibration in the adjoining crystal sections which make the smaller angle with each

other, so that the Becke effect is mainly due to the relation between their indices of refraction. The author discusses in detail the effect of the refractive indices of the different directions of vibration on the result.

CORRESPONDENCE.

SCANDINAVIAN ICE-SHEETS AND BRITISH GLACIAL DRIFTS.

Sir,—I thank Professor Bonney for the very kind way in which he refers to my letter on the Scandinavian ice-sheet. The question should, I agree with him, be approached without shirking difficulties. It would not be possible within the limits of this letter to discuss all the points he raises. I will, therefore, merely deal with the question as to whether, if sufficient ice passed off the Scandinavian Peninsula, it could flow across the deep Norwegian Channel and shallow North Sea and invade England. Professor Bonney says the main point for consideration "for our present purpose is the inadequate 'ramming' power of the ice from the Scandinavian upland, because by far the greater part of the journey to England would have been over land, not by water". If glacier ice be really viscous, the flow would not be the result of 'ramming' from behind. The movement would result from the absence of support in front. Again, he says, "Thus it must either have been forced up and over an undulating floor for over 350 miles before it reached the English coast, or its movement have been practically restricted to the upper layers." If such a form of flow took place, it would not be viscous flow. There would be a more or less steady gradient of the upper surface of the glacier rising from England to the Scandinavian uplands. The stresses due to the existence of this upper slope would act on every portion of the ice-sheet, and the bottom of the ice would drag the floor in the direction of motion even though the motion of the ice at the bottom were uphill. Ice will flow like water until its upper surface has become practically horizontal; but as the former has a viscosity of only 0·01 [1] c.g.s. 793 units, whilst the viscosity of glacier ice [2] is about 125×10^{12} c.g.s. units, water—if we do not consider the effects of inertia—would flow *cæteris paribus* as far in one second as glacier ice would in about 200,000,000 years. Now, if the water in the Norwegian Channel were raised about 100 feet, as Prof. Bonney suggests, and then suddenly released, it would invade England and carry material along the sea bed with it. Ice is not 'rammed' forward any more than water is rammed along a river bed. The spreading out in great sheets over the Antarctic Seas of the glaciers coming down from the Antarctic uplands is proof, I consider, that glacier ice in bulk behaves as a viscous substance, i.e. that the rate of shear is proportional to the stress even when the stress is exceedingly small. A great many very capable field geologists hold that there is ample evidence that an ice-sheet did invade England from the east and north-east, and I always understood

[1] Phil. Mag., 1909, p. 518.
[2] Roy. Soc. Proc., vol. lxxxi, p. 251.

that the main argument of their opponents was that it did not because it could be demonstrated that it could not, a view which I consider erroneous.

R. M. Deeley.

Melbourne House,
Osmaston Road, Derby.

THE DISCUSSIONS AT THE GEOLOGICAL SOCIETY.

Sir,—Referring to the letters of Dr. Davison and Mr. Hobson, would not the case be fully met, in the circumstance of the author not being present at the reading of his paper, if the Assistant Secretary were to send the author a copy of the abstract containing the discussion *with a request* that he would return any reply he might wish to make to be inserted as a postscript in the Quarterly Journal? I have myself been permitted to avail myself of this privilege in the case of my paper on the "Dewlish Elephant Trench" (vol. lxi, 1905), and can appreciate its sufficiency. If the author is present there is no hardship, for if his cause is a good one he can strengthen it by replying to his critics there and then, and his reply will appear in the Journal.

O. Fisher.

April 3, 1909.

OBITUARY.

FREDERICK GEORGE HILTON PRICE, F.S.A., F.G.S.

Born August 20, 1842. Died March 14, 1909.

We regret to record the death of Mr. Hilton Price, Director of the Society of Antiquaries, who, while distinguished as an archæologist, had also rendered important services to geological science. In 1860, at the age of 18, he entered the banking house of Messrs. Child & Co., Temple Bar, and eventually became head acting partner. With an intimate knowledge of business, of wide culture, possessed of a fine presence and of genial disposition, he was equally welcome on the council of the Bankers' Institute or on that of a learned society.

To the Geologists' Association in early years he gave much time and attention, and carried out the duties of treasurer from 1875 to 1881. He joined the Geological Society in 1872, and served on the Council for a short period in 1878–9. In later years his time, apart from business, was much occupied in archæological pursuits, including Egyptology and numismatics.

In his work upon the Gault Mr. Price was intimately associated with Mr. J. Starkie Gardner, F.G.S., and for many years they subsidized Griffiths, the well-known Folkestone collector, and made rich collections of the very finest Gault fossils. Mr. Gardner's collection was acquired by the British Museum, and Mr. Price's by his friend Mr. Hudleston, of which it still forms an integral part.

To geologists Mr. Price is best known through his detailed researches on the stratigraphy and palæontology of the Gault of Folkestone. He divided the formation into eleven zones, excluding

that of *Ammonites mammillaris*, Schloth. (now generally noted as *A. mammillatus*), which he placed with the Folkestone Beds at top of the Lower Greensand. In this respect he followed C. E. De Rance, who in 1868 communicated to the GEOLOGICAL MAGAZINE a paper "On the Albian, or Gault, of Folkestone"[1], in which the zones in the English Gault were for the first time deciphered.

Some of the zones marked out by Mr. Price are now regarded rather as sub-zones[1]; nevertheless, by his painstaking and enthusiastic researches, he added very largely to our information, and extending his knowledge to other regions he was enabled to publish in 1879 a memoir on "The Gault", which embodied his detailed observations at Folkestone, and included descriptions of the formation elsewhere in England and France, with a full list of fossils.

In his paper of 1877 he dealt with the so-called Upper Greensand of Folkestone, showing that the fauna belonged to the basal portion of the Chalk, and he termed this division the zone of *Stauronema Carteri*. It is regarded by Mr. Jukes-Browne as the stratigraphical equivalent of the Chloritic Marl as now defined in the Isle of Wight.[2]

The following is a list of Mr. Price's geological papers:—

1872. (With W. H. HUDLESTON.) "On Excavations on the site of the new Law Courts": Proc. Geol. Assoc., vol. iii, pp. 43–64, with descriptions and figures of two new species of Gasteropoda from the London Clay.

1873. "On a new species of *Rostellaria* from the Gault" [*Rostellaria maxima*, Price, Folkestone]: GEOL. MAG., pp. 97, 98.

1874. "On the Gault of Folkestone": Quart. Journ. Geol. Soc., vol. xxx, pp. 342–66, pl.

"On the Lower Greensand and Gault of Folkestone": Proc. Geol. Assoc., vol. iv, pp. 135–50.

1875. "On the probable Depth of the Gault Sea": ibid., vol. iv, pp. 269–78.

1876. "Excursion to Sandgate and Folkestone": ibid., vol. iv, pp. 554–6.

"Note on an Annelid Bed in the Gault of Kent": GEOL. MAG., pp. 190–1.

1877. "On the Beds between the Gault and Upper Chalk near Folkestone": Quart. Journ. Geol. Soc., vol. xxxiii, pp. 431–45.

1879. "The Gault, being the substance of a lecture delivered in the Woodwardian Museum, Cambridge, 1878, and before the Geologists' Association, 1879": 8vo, London, p. 81.

1881. (With W. J. MORRIS and E. B. TAWNEY.) "Excursion to the East End of the Isle of Wight": Proc. Geol. Assoc., vol. vii, pp. 185–9.

1886. "The Landslip in the Warren near Folkestone" [letter]: GEOL. MAG., p. 240.

1893. (With T. LEIGHTON.) "Excursion to Hythe, Sandgate, and Folkestone": Proc. Geol. Assoc., vol. xiii, pp. 142–51.

H. B. W.

MISCELLANEOUS.

THE LATE MR. W. H. HUDLESTON.—We learn that by his will Mr. Hudleston has left his unrivalled collection of types of Oolitic Gasteropoda to the Sedgwick Museum, Cambridge, and he has bequeathed £1,000 to the Geological Society.

[1] See Jukes-Browne, *Cretaceous Rocks of Britain*, Mem. Geol. Survey, 1900, vol. i.

[2] *Op. cit.*, 1903, vol. ii, p. 15.